AN INQUIRY INTO THE ONTOLOGY OF RESPONSIVENESS: ASSESSING EMBODIMENT AND HUMAN-MACHINE INTERACTION IN RESPONSIVE ENVIRONMENTS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

BAŞAK UÇAR KIRMIZIGÜL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
ARCHITECTURE

SEPTEMBER 2011

Approval of the thesis:

AN INQUIRY INTO THE ONTOLOGY OF RESPONSIVENESS: ASSESSING EMBODIMENT AND HUMAN-MACHINE INTERACTION IN RESPONSIVE ENVIRONMENTS

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ABSTRACT

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IN RESPONSIVE ENVIRONMENTS

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September 2011, 218 pages

Advances in communication and information technologies, as well as recent developments in computer technology, material research and sensor networks instigate the studies on active and dynamic environments, which call for the participation of the human and the machine in the definition of responsiveness in architecture. The thesis aims to provide for an ontological inquiry on responsiveness and responsive environments by undertaking an overview of the extensive interest in the responsive experience in architecture. It scrutinizes the field of responsive environments with a particular focus on the machinic approaches that (re)problematize the human-machine interaction. For this purpose, the thesis relates the concept of responsiveness with the machinism debate and considers the associations between the body, the human-machine interaction and the condition of embodiment in responsive environments.

The machinism debate is discussed in reference to responsiveness and assesses the issue of embodiment and human-machine interaction in responsive environments. By reflecting on the human-machine interaction, the re-conceptualization of the issue of embodiment is rendered in reference to the body, the definition of which arises from the relations between the body, the environment and the machine, continuously updated during their interaction. The thesis identifies this altered concept of the body as a significant stimulation for new modes of human-machine interaction as it enables the embodiment of relations in relation to the body and initiates the re-conceptualization of both embodiment and human-machine interaction.

In this respect, the thesis presents an assessment of the nature of human-machine interaction and its re-problematization in responsive environments, where the challenged conditions of body and embodiment are discussed in reference to debates in the philosophy of mind on different interpretations of the mind-body relationship. Referring to particular examples from different periods and contexts, the consequences of embracing machinic approaches in the definition of responsive environments are considered, where the dissolution of dichotomies between human and machine, subject and object, human and non-human, and mind and body are questioned in line with these transformations.

Keywords: Responsiveness, responsive environments, body, embodiment, machinic approaches, human-machine interaction.

ÖZ

YANIT VEREN ORTAMLARIN ONTOLOJİSİ ÜZERİNE BİR ARAŞTIRMA: CİSİMLEŞMENİN VE İNSAN-MAKİNA ETKİLEŞİMİNİN DEĞERLENDİRMESİ

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Eylül 2011, 218 sayfa

İletişim ve bilgi teknolojisindeki gelişmelerle birlikte bilgisayar teknolojisi, malzeme araştırması ve algılayıcı ağlarındaki gelişmeler yanıt verirliliğin insanın ve makinanın katkısıyla tanımlandığı aktif ve dinamik ortamlar üzerine yapılan çalışmaları tetiklemektedir. Tez, mimarlıkta yanıt verir ortamlara olan yaygın ilgiyi değerlendirerek, yanıt verirliliğin ontolojisini sorgulamayı amaçlamaktadır. Bu amaç doğrultusunda mimarlıkta yanıt verir ortamlar irdelenmekte ve insan-makine ilişkisini yeniden sorunsallaştıran makinesel yaklaşımlar üzerinde durulmaktadır. Bu bağlamda, yanıt verir ortamlarda beden, insan-makine etkileşimi ve cisimleşme kavramı arasındaki ilişki göz önünde bulundurulmakta ve yanıt verirlilik kavramı makine tartışması ile ilişkilendirilmektedir.

İnsan-makine etkileşiminin derinlemesine incelenerek cisimleşme kavramının beden, ortam ve makine arasındaki ilişkilerle tanımlanan ve etkileşim süresince kendini güncelleyen bedene referansla yeniden kavramsallaştırıldığı belirtilmektedir. Yeniden tanımlanan beden kavramı, ilişkilerin bedene referansla cisimleşmesini mümkün kılmakta ve cisimleşmenin ve insan-makine etkileşiminin yeniden kavramsallaştırılmasına işaret etmektedir. Bu nedenle beden kavramının yeniden tanımlanması insan-makine etkileşimi için önemli bir sıçrama olarak değerlendirmektedir. Yeniden tanımlanan beden ve cisimleşme kavramları zihin felsefesi'nde zihin-beden ilişkisini ele alan farklı yaklaşımlar gözönünde bulundurularak tartışılmakta ve insan-makine etkileşiminin doğası ve yanıt verir ortamlarda yeniden tanımlanan sorunsalı değerlendirilmektedir.

Farklı bağlam ve zamanlara ait örnekleri inceleyen çalışma, yanıt verir ortamların tanımında makinesel yaklaşımların benimsenmesinin beraberinde getirdiği değişimleri sorgulamakta ve insan-makine, özne-nesne, insan-insan olmayan, zihin-beden gibi ikiliklerin erimesini bu değişimler bağlamında değerlendirmektedir.

Anahtar sözcükler: Yanıt verirlilik, yanıt verir ortamlar, beden, cisimleşme, makinesel yaklaşımlar, insan-makine etkileşimi.

ACKNOWLEDGMENTS

I would like to express my deepest gratitude to my thesis supervisor Prof. Dr. Zeynep Mennan for her guidance, intellectual support, stimulating suggestions and contributions throughout this study. Her encouragement and insight have guided me in all stages of the study.

I am thankful to the examining committee members for their contributions. Assoc. Prof. Dr. Bahar Şener Pedgley and Assoc. Prof. Dr. Mine Özkâr, who are the members of my thesis supervising committee, offered stimulating suggestions and inspiring discussions since 2008. Assist. Prof. Dr. Meltem Aksoy and Assist. Prof. Dr. Namık Günay Erkal provided valuable comments and on the thesis defense.

I would like to express my gratitude to François Roche not only for his time and consideration, but also for the generous discussion and invaluable intellectual inspiration he provided me with during the interview I conducted with him in Paris, in January 2010.

I offer sincere thanks to my family; my parents Nilüfer Uçar and Hasan Uçar, and my brother Ekin Uçar for their support and encouragement at all aspects of life. My gratitude can never be enough.

I am grateful to my friends Tuba Çıngı, Güney Çıngı, Fırat Çıngı, Burcu Özyurt, Gökhan Özyurt, Pınar Pişkin and Mehmet Ali Pişkin for their continuous support and criticisms at all times. I would like to mention my gratefulness to Esin Kömez for her friendship, collaboration, and academic support. I am also sincerely thankful to my colleagues Aslıhan Günhan, Duygu Tüntaş, Leyla Etyemez, Seray Sever, Pınar Aykaç, Onur Özkoç, Yiğit Acar and Özgün Özçakır for their presence and support.

I want to express my special thanks to my husband Uğur Kırmızıgül, who always shared my excitements and enthusiasm in all aspects of my life. I could not have completed this research without his constant love and encouragement.

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CHAPTER 1

INTRODUCTION

Technological developments, especially the increasing influence of communication and information technologies on design and production processes lead to essential re-definitions in the organization and definition of built environments. Architecture and the built environment, having close relationships with technology, science, engineering and philosophy, are able to promote new self-conceptions and uses as consequences of advances in these fields. Mutually affecting each other, advances in computing, sensing devices and engineering knowledge bring forth new reflections and new fields of research on/in architecture; the use of responsive technologies is one such field that introduces and develops the idea of responsiveness in architecture.

Emerging progresses in sensing technologies, information technologies, artificial intelligence, computation theories and material properties are followed by new experiences in the definition of spatial experiences and built environments that increasingly address dynamic, flexible and responsive qualities. Environments making use of these advances can be asserted to respond effectively to the changing conditions, as well as the social interactions and behavior of their participants.

The search for an environment that responds to changes is not only a result of technological developments, but also a reflection of intellectual transformations and the consequently altering/altered contemporary life, in which the social, economic, cultural, and technological contexts can be seen to transform at an increasing rate. These changes affect the experience of the environment as well as the way participants use and relate themselves to the environment. As an expression of these transformations and advances, responsive environments emerge as a design and research field in the recent decades, where developments in several fields such as computer science, information and communication technologies intersect with architecture.

At this intersection, machines enable the interaction between humans and the environment and define the responsiveness of the environment. Responding dynamically to changing conditions through the use of machines and real-time data processing methods, environments can express a responsiveness that calls for new ways of designing, building and inhabiting the environment. By sharing and exchanging the information gathered and produced, responsive environments provide a new mode of communication between the human and the environment, as well as between information and environment. This advanced communication that allows responsive environments to attain a desired adaptability and a harmonious interaction between different parties is provided by machines.

In the emerging experience of responsive environments in the last two decades, the notion of responsiveness and interaction goes beyond that of a computer responding consequently to a given input, to start denoting a reciprocal relationship between the human and the machine. In a relationship where the parties of interaction respond to each other and redefine themselves according to the responses of other parties, the boundary between parties transforms itself and inherits the potential of being dynamic and permeable. In the constant redefinition of this boundary, neither the responsive mechanism, nor the participant can be regarded as passive receptors. Instead, they both act as dynamic and active parties, constantly adapting and redefining their reciprocal relationship, and where both parties can unfold like an extension of the other. The motivation for designing participatory responsive environments may bring about users' inquisitive engagement and definition of more dynamic environments. These are not only responsive and proactive, but also define the human as a responsive and proactive agent. With this drive, responsive environments offer the potential for triggering the human-machine interaction as well as interactions between the participants, their environment and wider networks of relations affecting them.

1.1 Problem Area and Definition

Research on responsiveness and responsive environments that emerged with the introduction of new technologies and recent developments in computing, sensing devices and engineering knowledge, have recently given way to the design and building of dynamic and flexible environments, which are able to respond to changing conditions in the environment and the user actions. Although the background developments that initiate the search for the concept of responsiveness can be traced from 1940s onwards (particularly in the works of Cedric Price in the 1970s), there is a remarkable increase in the number of studies that aim to attain the responsiveness of built environments, of which contemporary examples are observed mainly in the last two decades.

The studies questioning this extensive interest in the emerging experience of responsiveness and interaction are seen to consider mainly the pragmatist features of these environments and the experiences defined as a consequence of the interaction process between the machine and the human participant, where mimicking, replicating or predominating human performances are intentionally sought. However, their relation to the human remains rather ambiguous and the motivation behind the remarkable contemporary interest in responsiveness and the theoretical connotations of this interest are not clearly defined yet.

The exploration of this interest is substantial for understanding the ontological nature of the human-machine interaction in responsive environments. The study departs from this argument and traces in this respect the relation between these transformations and the definition of responsiveness to argue for a specific relation between these transformations and the conception of the machine. Through focusing more on the transformations, the study uncovers the reflections that the definition of responsiveness through machinic approaches might have on the human, the definition of the human body and the question of its embodiment. The thesis argues for the significance of adopting a philosophical approach to the question of responsiveness and responsive environments, that is claimed to overcome the shortcomings of a pragmatic/pragmatist one that would deal more with the efficiency of the interaction process, sustainability of the environment, effective use of sources etc. Rather than the technological advances themselves and the paths they opened for architecture, the study considers the effects of these advances on the human.

The main aim of the study is then to question the ontological significance of the interest in responsiveness through scrutinizing the field of responsive environments, where the nature of human-machine interaction is assessed through a conceptual mapping of the field: To this aim, the machinism debate is related with the idea of responsiveness and different approaches that (re)problematize human-machine interaction are considered. Through this mapping, it is aimed to reveal the redefinition of the body in responsive environments as emerging from the interactions between the human body, the environment and the machine, and to uncover the re-conceptualization of the issue of embodiment in reference to this altered definition of the body. The study reflects on human-machine interaction and discusses the altered experiences of body and embodiment in this interaction as proposed in responsive environments, where it is referred to particular examples from different periods and contexts. Along with that, the dissolution of dichotomies between human and machine, subject and object, human and non-human, and mind and body are questioned in reference to these transformations. Hence, the study traces the field with a different perspective and mainly through philosophical references in order to contribute to an understanding of the ontology of responsiveness through assessing the human-machine interaction and the issue of embodiment in responsive environments, specifically focusing on the examples proposed in the last decade.

Research carried on responsiveness and responsive environments is seen to display two significant conceptions of the machine that belong to different paradigms and different historicities; the machine as mechanism and the Deleuzian machine. A growing interest can be traced in the definition of responsiveness through mechanisms, that proposes mainly pragmatist stances and assesses the responsiveness of the environment in relation to the efficiency of the mechanism. Conception of machines as mechanisms offer a causal relationship between the parts of a mechanical system, each specialized in a specific function, and aim to transfer the forces effectively to accomplish the required work.[1] Research in the field of responsive systems/environments commonly embraces the use of machines as mechanisms, defining the coordination of parts in association to satisfy a common purpose. Defining instrumental solutions to the responsiveness concept, the widespread use of mechanisms can be traced in medical and military applications, as well as in architecture.

Rather than dealing with the use of machines as mechanisms and technical devices in the search for responsiveness of the environment, the present study focuses on the rather rare attempts at conceptualizing responsive systems/environments as Deleuzian machines that re-problematize embodiment and human machine interaction. The machines in these practices differ from mechanisms in the sense that "they make new connections in order to transform and maximize themselves, while connecting and reconnecting to

[1] Reuleaux, Franz. *The Kinematics of Machinery: Outlines of a Theory of Machines*. New York: Dover Publications, 1963.

different machine(s), which are also in evolution and mutation processes."[2] Deleuze and Guattari's understanding of the machine suggests the replacement of fixed and static conceptions of machines with heterogeneous and dynamic conceptions, which provide for their definition as "being in continual transition."[3] The study discusses the concept of the machine as developed by Deleuze and Guattari. In this sense, the approaches which embrace the concept of the Deleuzian machine in the definition of responsive environments are referred as 'machinic approaches' throughout the study. Considering what a machinic approach implies in general, the study questions how this approach can be utilized to attain the responsiveness of the environment referring to the contemporary examples of the last decade.

Machinic approaches to the responsiveness of the environment alter the human-machine interaction and define a dynamic, evolving, unpredictable and indeterminate interaction process as compared to the determinism of human-mechanism relationship. These approaches define the body as being in continuous transformation and enable the reflection of the relations redefined during these transformations to the environment through the responsive system. The body can thereby be extended to the environment and defined as a part of the environment. Equipped with computing strategies and sensor-network technologies, these environments exhibit a Deleuzian concept of the body as an embodiment of relations, intersubjectivity and contexts.[4] This conception can be considered as having significant influences on the definition of the body and the issue of embodiment, since it enables the embodiment of relations and contexts in different ways in relation to the body. This change necessitates the

[2] Colebrook, Claire. *Gilles Deleuze* (London; Routledge, 2002), 57.

[3] Grozs, Elizabeth "Deleuze, Bergson and Becoming." 2004. http://www.uq.edu.au/~uqmlacaz/ElizabethGrosz%27stalk16.3.05.htm. [Accessed: July, 2011].

[4] Schick, Lea and Malmborg, Lone. "Unfolding and Refolding Embodiment into the Landscape of Ubiquitous Computing." in *Digital Art and Culture Conference_ After Media: Embodiment and Context*. Proceedings, California, 2009.

re-conceptualization of the human-machine interaction and the conception of the machine so that it can trigger and also embrace this transformation. Therefore, it can be claimed that this conception of the body as unstable and inseparable from the environment introduces new experiences for the body and recasts the issue of human-machine interaction and that of embodiment.

In order to map these changes in the conception of the body and embodiment in responsive environments defined through machinic approaches, debates in the philosophy of mind are traced to consider different approaches to define the mind-body relationship. Concentrating particularly on the Deleuzian framework, it is tried to question the experienced changes in the conceptions of body and embodiment and understand their altered conditions during the interaction process defined between the machine and the human in responsive environments.

Deleuzian thinking does not differentiate between human or non-human, nor living or non-living bodies.[5] This re-conceptualization indicates a decentering of anthropocentrism that opens up with a post-humanist context, initiating the dissolution of the dichotomies between human and non-human as well as between human and machine. The decentered human body is no more distinguished from other bodies and is defined as being in a constant process of becoming, hence of redefinition.[6] Machinic approaches embraced in the definition of responsive environments reveal this Deleuzian definition of the body as continuously redefined and never considered as complete.[7]

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[5] Deleuze, Gilles. *Spinoza, Practical Philosophy* (San Francisco: City Lights Books, 1988), 127.

[6] Deleuze, Gilles, Guattari, Felix. *A Thousand Plateaus: Capitalism and Schizophrenia*. Minneapolis: Continuum International, 2004.

[7] Ibid.

The Deleuzian body is defined as being composed of a multiplicity of desiring-machines that connect with other desiring-machines.[8] Functioning like a desiring-machine, the body defines new connections, transforms the relations and produces new flows.[9] In this relation, the body is not defined as a single and fixed body, but instead as a dynamic being.[10] Responsive environments enable the definition of bodies as desiring-machines and the production of new connections, interruptions, relations and productions through the use of machines.

In the ever-evolving production process, the body is configured as a complex system of intersecting linear multiplicities (a rhizome), where it is continuously being renegotiated through dynamic relations.[11] The rhizomatic configuration of the body embraces a non-hierarchic becoming that does not have a subject nor an object.[12] Reflections of rhizomatic configuration can be traced in responsive environments, where multiple bodies such as machine, human, non-human, animate, non-animate participants of the interaction process are connected to each other in a non-hierarchic manner. Considering the further multiplicities embodied in these multiplicities, it can be claimed that responsive environments inherit the characteristics of a rhizome and propose the dissolution of hierarchic structures.

Hierarchies inherent in the mind-body or the subject-object dichotomies are then also subject to dissolve. This study examines the mind-body problematic in different philosophical paradigms to discuss the problematization of

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[8] Deleuze, Gilles, and Guattari, Felix. *Anti-Oedipus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 1983), 36-37.

[9] Ibid.

[10] Ibid, 17.

[11] Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 8.

[12] Ibid.

Cartesian dualism that assigns priority to the mind over the body. Leibnizian and Spinozian monism is delineated to understand the extent of the alterations the problematics of the body and embodiment have undergone under Deleuzian thinking, and the reflections of these alterations in terms of the human-machine interaction proposed in responsive environments.

Consequently, the thesis scrutinizes the machinic approaches that re-problematize the issue of embodiment and the human-machine interaction and challenge the concept of responsiveness and the definition of responsive environments. The exploration on the machinic approaches is guided by the discussions on the significant transformations defined through these approaches, such as the introduction of new experiences of body, embodiment and human-machine interaction, the dissolution of dichotomies and anthropocentrism together with the alterations in subject and object conditions as well as the methodological and epistemological changes introduced through these approaches. In this respect, the study suggests an alternative perspective to the research field and reveals the transformations defined through the acknowledgement of machinic approaches in the definition of responsive environments.

1.2 Methodological Approach and Structure of the Thesis

In order to question the ontology of responsiveness, it is referred to the debates in the philosophy of mind on the body and the issue of embodiment and it is aimed to grasp the re-problematization of the notion of embodiment in relation to the re-conceptualized human-machine interaction in responsive environments. In this respect, firstly, the concept of responsiveness and the technological developments that facilitate the definition of responsive environments are discussed. Secondly, the philosophical discussion of the mind-body problematic and the issue of embodiment is related with respect to different conceptions of the body. Thirdly, the machine concept and the machinism debate are elaborated in relation to contemporary examples that attain the responsiveness of the environment through machinic approaches. Depending upon these discussions transformations introduced by responsive environments are traced.

To give a more detailed account of the thesis structure, Chapter 2 focuses on the concept of responsiveness, where the relationship between the studies on responsiveness and the advances in communication and information technologies as well as sensing devices and material properties are discussed. A brief exploration of the specifications of responsive environments, which provides for an overlook to the technical part running at the backdrop of the system and reveals the strategies and tools that enable the definition of a machinic approach is introduced. This discussion is followed by an inquiry into the background developments that trigger the search for a responsive environment. In this respect, an overview of the developments that are associated with the search for responsiveness is provided: The history and development of cybernetics is traced and ubiquitous computing, augmented reality and virtual reality are considered subsequently as the main contemporary approaches embraced in the definition of responsive environments. Three influential projects that aim to define responsive environments are discussed in: *Fun Palace* and *Generator* projects designed by Cedric Price and the *Musicolour* project designed by Gordon Pask.

Chapter 3 considers the debates in the philosophy of mind with a specific focus on the mind-body relationship, where it is aimed to reveal the changes experienced in the definitions and conditions of body and embodiment in responsive environments. In order to understand the problematization of the concepts of body and embodiment in responsive environments, particularly focusing on the machinic approaches, it is referred in this chapter to cognitive science and the existing literature in the philosophy of mind on the mind-body relationship, traced in relation to dualism, monism, behaviorism and cognitivism, and where Spinoza's, Leibniz's and Merleau-Ponty's philosophies are highlighted. After a mapping of the historical connotations of the body and the issue of embodiment as a philosophical problem, it is referred to Deleuze's reconceptualization of this problem, of which reflections can be traced in machinic approaches. Following this discussion, the relationship between new technologies, computational approaches and the experience of embodiment are scrutinized in reference to wearable computing and smart materials, and ubiquitous computing, thereby aiming to question the body and the issue of embodiment that are altered during the interaction of the human with the machine in the responsive environment as well as the dissolution of the dichotomies between man and machine, human and non-human, subject and object.

Chapter 4 discusses the concept of the machine and the machinic approaches embraced in the definition of responsive environments, which introduce new experiences of embodiment, human-machine interactions and relationships between participants and environment. Underlying the differences between the machine and mechanism, this chapter traces the reflections of the Deleuzian body and machine on recent instances of responsive environments. In order to discuss the machine conception in relation to the re-problematization of embodiment and human-machine interaction, three concepts of machine are considered: Desiring machines, Bachelor machines and Schizoid machines. By considering these three different approaches, it is aimed to render the associations between the machine concept defined in these approaches and the machines used in responsive environments, while underlying their departure from mechanisms. Practices of machinic approaches in responsive environments are discussed in reference to four recent projects, which propose the conception of machines as initiators of transformations, new relationships, realities and experiences: The *Olzweg* and *An architecture "des humeurs"* projects by R&Sie(n), the *SYS*017.ReR*06/PiG-EqN\5*8* by Mathieu Briand and the *Hormonorium* by Jean-Gilles Decosterd and Philippe Rahm.

Transformations defined through the machinic approaches are discussed in relation to the altered definition of human-machine interaction, the disturbed relationship of the human with reality, and also the methodological changes initiated by such approaches.

CHAPTER 2

RESPONSIVENESS: RESPONSIVE TECHNOLOGIES AND CONTEMPORARY APPLICATIONS

The advances experienced in computer technology, material research and sensor networks have significantly influenced architecture and the experience of the environment. Practiced initially in the virtual medium, the conception of dynamic and responsive environments started to be practiced in the physical realm in the last decades. As the definition and experience of the environment alters in relation to these practices, the relationships between the environment and the participants begin to transform. These new relationships engender a new understanding and definition of the environment, where the environment and the participants are considered as responding to each other and to the relations defined between them. The studies on responsiveness and responsive environments are experienced parallel with the technological developments and with the theoretical studies in computation, cognition, interaction etc., where these developments and studies are affected from each other and shifts are experienced as a consequence of changes in any of the fields.

The introduction of the concept of responsiveness to architecture can be seen to stimulate a series of social, economic, cultural, technological or psychological changes in the definition of the environment. The environment that responds to these changes also affects these fields in a reciprocal relation. Through real-time data processing methods and advanced communication technologies, this reciprocal relationship enables to share and exchange information simultaneously. Responsive environments can hence offer the potential for facilitating interactions between participants, their environment and wider networks, as well as requiring an awareness of many different types of user, contexts, functions and social and environmental conditions.[13]

A responsive environment detects and delivers the experience and response of the participant during his/her interaction with the environment or the other participants. Providing the engagement with the participants and the other parties involved in the process, the responsive environment, with its assemblages of spatial and technical systems, acts like a translator and provocateur of certain experiences of feelings, emotions, behaviors, or states. The environment stimulates, and is in turn stimulated by the participant's behavior or other environmental inputs during the interaction process. Each party participating in the process affects the behavior of the environment, where the responses of the environment are defined in relation to the interactive process. This interactive relation between the parties is considered as an important feature of responsiveness that distinguishes the responsive solutions from the reactive ones.

This chapter focuses on the concept of responsiveness and the ways of exploring this concept in architecture. The discussions on this search highlight the distinctions between responsiveness, interactivity, artificial intelligence and provide for highlights in the current research carried on these concepts. Specifications of responsiveness and responsive environments are put forth where they are analyzed with references to several examples from different periods with different intentions. Following this research, the developments, which trigger the research on responsive environments are introduced, which is associated with an overview of the developments in cybernetics providing for the initial examples of responsiveness in architecture. Finally, contemporary approaches of sharing and exchanging information are considered in this

[13] Bullivant, Lucy. *Responsive Environments: Architecture, Art and Design* (London: Victoria and Albert Museum, 2006).

chapter, of which examples are ubiquitous computing, augmented reality, and virtual reality.

2.1 Responsiveness

2.1.1 Definition and Examples

The idea of responsiveness and being responsive to the changing circumstances has significant reflections on architecture and the built environment. Defined in ordinary language as the act of "answering to someone/something" or as "something constituting a reply or a reaction," a response points out to the ability of reacting to the current and changing circumstances.[14] Therefore responding to and being responsive finds its place in architecture in the sense that a responsive architecture is defined mainly as "a class of architecture or building that demonstrates an ability to alter its form, to continually reflect the environmental conditions that surround it."[15] However, the term responsive architecture was first used by Nicholas Negroponte and was proposed as "the natural product of the integration of computing power into built spaces and structures."[16] Extending this definition, Negroponte also assumes that concepts of "recognition, intention, and variation" would be integrated to responsive architecture challenges.[17]

Parallel to the definition of Negroponte, most of the contemporary applications of responsive applications include sensitive environments, which are enabled through the complex network of various components. Making use of computers

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[14] Encyclopaedia Britannica. http://www.merriam-webster.com. [Accessed: March, 2011].

[15] d'Estrée Sterk, Tristan. "Using Actuated Tensegrity Structures to Produce a Responsive Architecture." In *Annual Conference of the Association for Computer Aided Design In Architecture*, Proceedings, 85-93. India, 2003.

[16] Negroponte, Nicholas. *Soft Architecture Machines* (Cambridge, MA: MIT Press, 1975).

[17] Ibid.

and computational theories, these components work in unity with each other and provide the desired variations and adaptations. In this way, the network becomes sensitive to the information received from the user/environment and adapts/reorganizes itself accordingly.

Although associated mostly with the influence and use of the computer, responsiveness does not always have to be supported by computer authority. The proposed mechanism may respond to the changing conditions in a kinetic way or only by means of material qualities without displaying a computational behavior supported by computer mediated systems. There are various instances of attaining responsiveness without making use of computer technology; vernacular architecture can be considered as one of them. Vernacular architecture, through utilizing available resources and specific construction techniques, addresses particular needs and evolves over time to adapt to the changing environmental, structural, cultural or economic requirements.[18] Hence, vernacular architecture can be said to accommodate the responsiveness of the structure/environment in unique ways.

A mechanism that alters its form as a consequence of the change in the environment (for instance wind, pressure, density etc.) can also be considered as responsive, although it does not depend on computer support. Such a response is supposed to be a "kinetic response"[19] or an "internal response," and still considered to present responsive behavior.

An example of kinetic response is the wind responsive facade design by Cepezed architectural office in collaboration with Ned Kahn Studios. Designed

[18] Asquith, Lindsay and Vellinga, Marcel. "Introduction." *Vernacular Architecture in the Twenty-first Century: Theory, Education and Practice* (London; New York: Taylor & Francis, 2006).

[19] Sherbini, Khaled and Krawczyk, Robert. "Overview of Intelligent Architecture." In *eDesign in Architecture: ASCAAD's First International Conference on Computer Aided Architectural Design*, Proceedings, Saudi Arabia, 2004.

for the facade of an office building in Utrecht, Netherlands in 2008, the responsive surface (figure 1) is made of stainless steel mesh with thin transparent plastic disks.[20] These disks are suspended from stainless steel cable nets and undulate in the wind.[21] In accordance with the wind present in the environment, the mesh on the facade of the building vibrates and hence the disks ripple while creating intricate patterns of light.[22] Therefore, the facade proposal responds to the change in the physical environment through its structural and material properties without using any computer supported apparatus.

Figure 1: Wind responsive facade is design by Cepezed in collaboration with Ned Kahn Studios and constructed in 2008 in Netherlands.

Source: Khan, Ned. http://nedkahn.com/wind.html#fragmentedSea. [Accessed: March, 2011].

On the other hand, an example of internal response provided by material properties is the shade proposal by Lance Hosey designed for "Next

[20] Khan, Ned. http://nedkahn.com/wind.html#fragmentedSea. [Accessed: March, 2011].

[21] Cepezed. http://www.cepezed.nl. [Accessed: March, 2011].

[22] Khan, Ned. http://nedkahn.com/wind.html#fragmentedSea. [Accessed: March, 2011].

Generation Design Competition" in 2005. Exploiting the inherent properties of the materials, Hosey's *Smart Shade* proposal makes use of composite layers of zinc and steel to control the amount of sunlight passing into the building's interior (figure 2).[23] Since these two materials (zinc and steel) have different thermal tendencies, the amount of expansion and contradiction of these materials according to the temperature change differ from each other. Contraction and expansion of the zinc and steel layers make the blinds move upward and downward and control the amount of sunlight let in.[24] They expand in high temperatures and prevent the sunlight pass into the building, while contract in low temperatures and letting more sunlight into the building.[25] Therefore, it is proposed that the shading elements express their response to the environment through the material properties, without accommodating any computer generated feature.

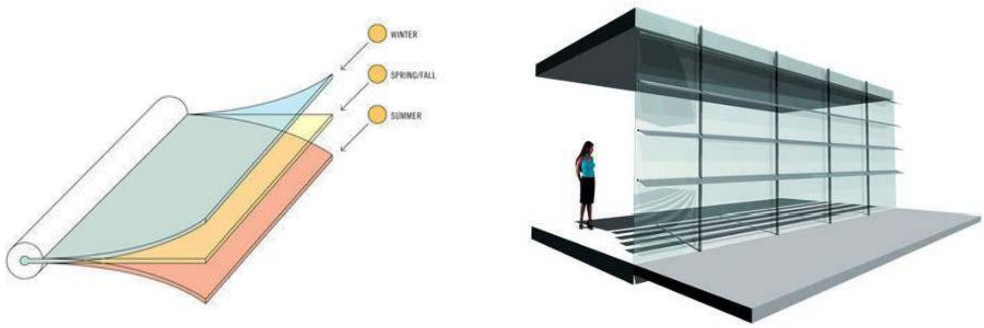

Figure 2: Smart Shade project by Lance Hosey.

Source: Metropolismag. "Living, Breathing Buildings: Envisioning Architecture that Performs Like Natural Organisms." http://www.metropolismag.com/story/20051219/living-breathing-buildings. [Accessed: March, 2011].

[23] Metropolismag. "Living, Breathing Buildings: Envisioning Architecture that Performs Like Natural Organisms." http://www.metropolismag.com/story/20051219/living-breathing-buildings. [Accessed: March, 2011].

[24] Ibid.

[25] Ibid.

The responsiveness of the environment may also inherit a computational behavior that is satisfied with computer technologies. Although the responsiveness concept is not new in architecture, with the use of computers and computer technologies in the definition, it is considered as a new concept in architectural discourse. In cases where responsiveness is defined through computer technologies, the environment gains the ability to respond to the changing conditions or stimuli from different sources according to the processed information gathered from the environment. The computational behavior can be included at any phase of the responsive process; gathering information from the environment, processing the gathered information or providing a response to the environment. In such kind of proposals, the environment and/or the human interact with the mechanism that absorbs and translates the information into visual, formal, aural expressions.[26] Implying an interaction between the environment and the defined software, in such mechanisms, sets of relations are defined considering the possible patterns or behaviors provided by the environment such as density, sound, movement, temperature, humidity, and luminosity.[27] Besides, their possible counter-reactions are also taken into account. These relations are activated by the sensing components such as sensors and emitters that trace the information provided by the environment and/or the human and channel their flow. Capturing the interactions between the environment, the human and the responsive system, these sensing components enable the direct fusion of information.[28] Hence, the system that is infused with information proposes simultaneous response of its interaction with the environment and/or the human.

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[26] Hookway, B. and Perry, C. "Responsive Systems | Appliance Architectures." *AD: Collective Intelligence in Design*. Vol. 76 No. 5 (December 2006): 74-79.

[27] Biloria, Nimish. "Developing Concept Prototypes for Electronic Media Augmented Spatial Skins-An Investigation into Biotic Processes, Material Technologies and Embedded Computation for Developing Intelligent Systemic Networks" in *9th International Conference on Computer Aided Architectural Design Research in Asia*, Proceedings, Seoul Korea, 2004.

[28] Ibid.

This simultaneous response can be considered as the representation of a dialogue between different parties of interaction; the system and the environment. During this dialogue, the response of the system or the environment may also indicate a change in the medium of information gathered. Since the relations, control mechanisms and coding theories, define the dialogue between the gathered information and the response to it, the medium of the information gathered does not have to be the same with its provided response. For instance, a responsive systems' or environments' output capturing the movement traces in the environment may be in terms of an auditory/visual representation. Such a translation in the medium of the information may define new experiences for both the user and the environment. Both parties can be affected and reconfigured from these changes and responses, hence provide a constant change in their responses to each other.

In the *Dune 4.0* project (figure 3), designed in 2006 by Daan Roosegaarde and exhibited first in Rotterdam, a responsive environment is proposed for public spaces, which alters its behavior in accordance to the human presence of movement and sound.[29] In this project, responsiveness is provided with the computational behavior of the proposed system, where mechanical components are used and software is provided to trigger responsiveness. The proposal is composed of fibers that react to the movements and sound of the human passersby, traces the information through microphones and components sensing the presence of the visitors.[30] Through the information gathered from the environment, the particular software is triggered and a visual response made up of movement and lighting patterns is provided.[31] According to the environmental conditions, the lighting and moving patterns of fibers change and propose a dynamic and responsive environment. The *Dune* "goes crazy"

[29] Bullivant, Lucy. "Alice in Technoland." *AD: 4dsocial: Interactive Design Environments*. Vol. 77 No. 4 (July 2007): 7.

[30] Ibid.

[31] Ibid.

when there is a lot of noise or movement and "falls asleep" when there is no change in the environment or even when there is continuous state of information such as the continuous "zooming" noise of a ventilator. [32] Therefore, in the *Dune 4.0* project, various moods can be defined that oscillate between asleep and crazy moods as a response to the information change in the environment.

Figure 3: Dune 4.0 by Daan Roosegaarde.

Source: Bullivant, Lucy. "Alice in Technoland." *AD: 4dsocial: Interactive Design Environments.* Vol. 77 No. 4 (July 2007): 6-13.

On the other hand, responsiveness can also be provided with some responsive materials operating at molecular level and reacting to environmental stimuli. Called "smart materials", these responsive materials express their response with particular changes in their properties, functions or structure or

[32] Roosegaarde, Daan. "Dune 4.0." http://www.studioroosegaarde.net/. [Accessed: March, 2011].

composition.[33] An example of attaining responsiveness through these smart materials is the *Reef* project (figure 4-5) by Rob Ley and Joshua Stein, which was recently on display in 2009 at the storefront for Art and Architecture in New York and in 2010 at the Taubman Museum of Art.[34]

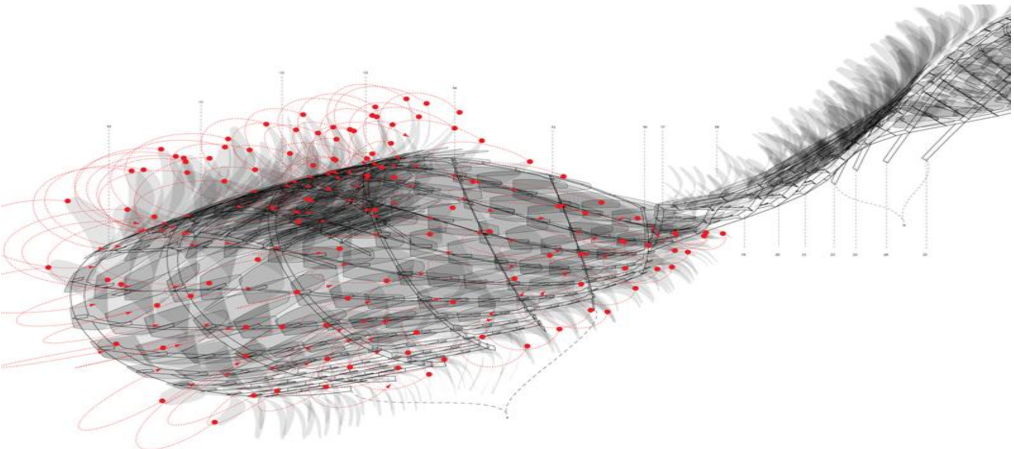

Figure 4: The performance detail of Reef installation by Rob Ley and Joshua Stein which investigates the interaction between emerging material technologies and architectural and public space.

Source: Reef. http://www.reefseries.com/.[Accessed: March, 2011].

Being a responsive installation that updated itself to adjacent social conditions, the *Reef* uses shape memory alloys (SMAs) and makes use of the potentials of emerging material technologies. Shape memory alloys are considered as a new category of metals which change shape, however remember their original shape and can return to their pre-deformed shape after deformation.[35] Acting as a wall between the public and private space, the *Reef* creates an interior

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[33] Reece, Peter L. *Progress in Smart Materials and Structure* (New York: Nova Science Publishers, 2007).

[34] Reef. http://www.reefseries.com/.[Accessed: March, 2011].

[35] Addington, D. Michelle. *Smart Materials and New Technologies: For the Architecture and Design Professions* (Boston: Architectural Press, 2005).

condition by reacting to the changes in the street.[36] The responsive membrane acting as a wall provides for a diverse range of arrangements of the fins and enclosure patterns in reference to the population of passersby.[37] As more people gather on the street, the fins open accordingly and offer increased levels of interaction between the exterior and interior.[38] Different arrangements of fins provide different opacity levels and visual transparency intensities, which also affect the perception of the built environment and the interface between different parties of interaction.[39] The shape memory alloys in the fins enable the structure to return to its pre-deformed shape and also react to the change in the stimuli from the environment; in this case it is the population of the passersby at the street.[40] Therefore, in the *Reef* installation, responsiveness is provided with post-material properties which are not inherited in the original properties of the material but gained with technological interventions.

Figure 5: Reef installation by Rob Ley and Joshua Stein which was on display at the storefront for Art and Architecture in New York in 2009.

Source: Reef. http://www.reefseries.com/.[Accessed: March, 2011].

[36] Reef. http://www.reefseries.com/.[Accessed: March, 2011].

[37] Ibid.

[38] Ibid.

[39] Ibid.

[40] Ibid.

The responsive installation acts like a mutating mediator, updates and redefines itself continuously according to the negotiation between the informative environment and the interface. Since the interface re-structures itself according to the changes in the environment, it may be regarded as an active informational environment, with in-built response and sensing abilities. Therefore, it is possible to assert that a new environment and new experiences are defined through the idea of responsiveness, which are in constant evolution through a continuous feedback loop and update themselves simultaneously.

2.1.2 Distinctions between Machine and Mechanism

In the contemporary definition of responsive environments, arrangements of machines are used, which enable the causal relationship between different parts of the system, human and environment. Interrelated parts of these machines facilitate the sensing, processing and actuation processes and hence define the responsiveness of the environment. However, different concepts of machines and the association of these concepts with the responsive environments can bring forth altered experiences in the current architectural design practice. Marking this shift in the conception of the machine, this thesis underlines the distinction between the use of machines or mechanisms in responsive environments.

Machine conceptions have always gone parallel with the cultural and technological developments throughout time and therefore have different definitions according to the context they are defined in. There are numerous definitions of the machine, which hardly ever agree with each other. Robert Willis, from an engineer's perspective states that "every machine will be found to consist of a train of pieces connected together in various ways, so that if one be made to move, they all receive a motion, the relation of which to that of the first is governed by the nature of the connection."[41] Thomas M. Goodeve, with a similar approach, defines a machine as "an assemblage of moving parts, constructed for the purpose of transmitting motion or force, and of modifying, in various ways, the motion or force transmitted."[42] From a mathematician's point of view, the machine is defined as an instrument, "by means of which pressure or motion may be transmitted from one point to another, and altered both in magnitude and direction."[43] Lewis Mumford in *The Myth of the Machine* defines the machine as "a combination of resistant parts, each specialized in function, operating under human control, to utilize energy and perform work."[44] Mumford's attempt to conceptualize the machine differs from the other technical definitions in the sense that he intends to fuse the mechanization of things and social relations.

Apart from these attempts, the definition of a machine by Franz Reuleaux, is considered as one of the important attempts to provide a complete definition. Reuleaux was a German mechanical engineer and a lecturer of the Berlin Royal Technical Academy, who is best known for his studies on the morphology of machines and kinematics. In *The Kinematics of Machinery* (1875), he defined the machine as "a combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinate motions."[45] This definition provides a determined and causal relationship between the parts of the mechanical system each specialized in a specific function, where it is aimed to transfer the forces effectively to accomplish the required work.[46] Although it is not stated directly,

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[41] Willis, Robert. *Principles of Mechanism* (London: Oxford University Press, 1951).

[42] Goodeve, Thomas. M. *The Elements of Mechanism* (London: Longman and Green, 1912).

[43] Galbraith, J.A. and Haughton, S. *Manual of Mechanics* (London: Cassell, 1871).

[44] Mumford, Lewis. *The Myth of the Machine* (New York: Harcourt, Brace & World, 1967).

[45] Reuleaux, *The Kinematics of Machinery: Outlines of a Theory of Machines*.

[46] Ibid.

a system is described here through the idea of the machine, where all parts are closely related to each other.

The machine can also be examined out of its technical context and can be regarded as an arrangement of technical, bodily, intellectual, and social components. The main motivation of this argument is the conception of the machine by Gilles Deleuze and Félix Guattari, one which is distinguished by not being taken exclusively in its mechanistic and technical connotation. In *Anti-Oedipus: Capitalism and Schizophrenia*, Deleuze and Guattari define the machine as a system of interruptions and breaks, where every machine is the machine of a machine.[47]

Deleze and Guattari provide a new conception of the machine and put forward a definition that can be discussed in different contexts such as sociology, economy, art, architecture, etc. However, it is important to make the distinction between the machine described here and the mechanism, since their distinction is important in understanding the Deleuzian notion of the machine. In *Anti-Oedipus: Capitalism and Schizophrenia and A Thousand Plateaus*, Deleuze and Guattari define their concept of the machine and distinguish machine from mechanism and machinic from mechanistic, since they have almost opposite connotations. They emphasize that the machine has no closed identity and specific function whereas the mechanism can be considered as a closed machine with a specific function.[48] Therefore, although machines make new connections in order to transform and maximize themselves, mechanisms represent the frozen states of these continuous transformations.[49]

[47] Deleuze and Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*, 38-39.

[48] Colebrook, *Gilles Deleuze*, 56.

[49] Ibid.

A detailed discussion of the Deleuzian concept of the machine will be provided in the fourth chapter. In this chapter, it is mainly focused on mechanisms and mechanistic solutions employed in responsive environments and it is tried to underline the distinctions between machines and mechanisms. As a mechanism is a machine in its mere technical connotation, mechanisms are commonly defined as "entities and activities that produce regular changes form start up to termination." [50] Provided by Peter Machamer, Lindley Darden and Carl Craver, this definition understands the mechanism as an organized set of correlated parts.[51] Similar to this definition Bechtel and Abrahamsen define the mechanism as "a structure performing a function in virtue of its components parts, component operations, and their organization. The orchestrated functioning of the mechanism is responsible for one or more phenomena." [52]

According to Bechtel and Abrahamsen, mechanistic explanations begin with the identification of phenomena to be clarified, where the entities relevant to the phenomenon are decomposed and reorganized to produce the phenomenon. [53] These entities are the parts of the mechanism that are active in bringing about a given phenomenon.[54] According to Stuart Glennan, "mechanisms underlie behaviors. The behavior that the mechanism underlies, or more simply, the behavior of the mechanism, is what the mechanism does."[55] The

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[50] Machamer, P., Darden, L. and Craver, C.: 'Thinking about Mechanisms.' *Philosophy of Science*. Vol. 67 No. 1 (March 2000): 1-25.

[51] Ibid.

[52] Bechtel, W. and Abrahamsen, A. 'From Reduction Back to Higher Levels,' in *30th Annual Conference of the Cognitive Science Society*, Proceedings, 559-564. Austin, Texas, 2008.

[53] Ibid.

[54] Machamer, Peter. 'Activities and Causation: The Metaphysics and Epistemology of Mechanisms.' *International Studies in the Philosophy of Science*. Vol. 18 No. 1 (March 2004): 27-39.

[55] Glennan, Stuart.'Modeling Mechanisms.' *Studies in the History and Philosophy of Biology and Biomedical Sciences.* Vol. 36 No. 2 (June 2005): 443-464.

mechanism defined for a specific behavior is a complex structure composed of several parts that produces the behavior through the interaction of parts.[56]

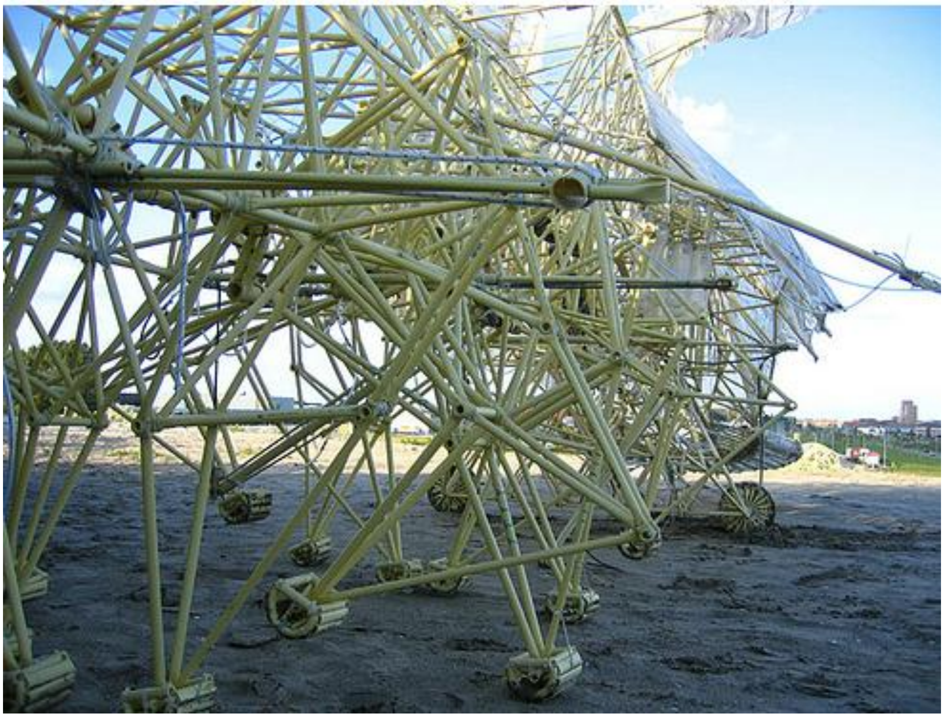

Figure 6: A mechanism designed by Theo Jansen as a kinetic sculpture.

Source:Jansen, Theo. http://www.strandbeest.com. [Accessed: March, 2011].

With these properties, identifications provided about mechanisms resemble to the descriptions of machines, since they are both composed of various parts that interact with other parts, and produce an end result. However, this thesis underlines the distinctions between machines and mechanisms to focus on responsive environments that consider the machine as a strategy rather than a tool producing new connections, flows, interruptions, and opening up new formations. Several examples provided for discussing the responsiveness idea

[56] Glennan, Stuart.'Rethinking Mechanistic Explanation.' *Philosophy of Science*. Vol. 69 No.3 (September 2002): 342-353.

in the current architectural practice define the machines as mechanisms and place emphasis on the efficiency of production and performance.

2.1.3 Responsiveness through Responsive Mechanisms

The arrangement of a responsive mechanism can be considered as a network of components that work in coherence with each other in order to attain the desired flexible, adaptive and dynamic behavior.[57] Creating a self-organizing network, responsive mechanisms are composed of entities that process data simultaneously.[58] These data processing entities are also linked to the other parts of the mechanism and thus provide a network of relations capable of updating the mechanism in real time. Therefore, enabled via such an association of elements, these mechanisms provide for a continuous communication with the environment and the participant. The network that facilitates this communication is mainly composed of three main phases; sensing, processing and actuation.

Processed through these three phases, the information traced and gathered from the environment and participant via the sensing capabilities of the mechanism is transmitted to the processing part, where an output is formulated based on the already defined relations and an output is produced as the response of the mechanism to the environment and participant. On the other hand, mechanisms responding without executing the processing phase and making use of control systems pursue a different approach. In such cases, the sensing and processing phases are bypassed and only the actuation phase is performed. The changes in

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[57] Hookway and Perry, "Responsive Systems | Appliance Architectures," 74-79.

[58] Biloria, Nimish. "Emergent Technologies and Design: An Investigation into Biotic Processes, Material Technologies and Embedded Computation for Developing Intelligent Systemic Networks," in *23rd eCAADe Conference (Education and research in Computer Aided Architectural Design in Europe),* Proceedings, 441-447. Lisbon, 2005.

the formal or material properties are mostly a consequence of the mechanism's innate features or the formation and organization of the proposed structure.

The sensing phase in responsive mechanisms is associated with the use of sensory devices, which give the mechanism the ability to sense or being aware of someone, or something (the environment). However, in responsive mechanisms, the faculty of perceiving the information is enacted through sensors and sensor-like devices, which are capable of recognizing, identifying and tracking the information. Sensors can be defined as "devices that detect or respond to perceive the presence or properties of things".[59] Detecting and collecting the information from the environment in different ways, sensors act as if they are the neural networks for the whole mechanism.[60]

Although there are different categories of sensing performance varying according to the discipline and performance criteria, a sensing system generating input signals is loosely divided into two categories; active and passive sensing. An active sensing system includes actuators and sensors; it sends out an indication and monitors a response to it.[61] Through active sensing, it becomes possible to make observations and track information through emitting information into the environment and detect the direct response from

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[59] Addington, *Smart Materials and New Technologies: For the Architecture and Design Professions*, 114.

[60] Sherbini, Khaled and Krawczyk, Robert. "Overview of Intelligent Architecture." In *eDesign in Architecture: ASCAAD's First International Conference on Computer Aided Architectural Design*, Proceedings, Saudi Arabia, 2004.

Although there are many types of sensors, which can be categorized under different classes according to their area of use, the basic sensor types used most frequently are; light sensors, sound sensors, thermal sensors, humidity sensors, touch sensors, position sensors, proximity sensors, motion sensors, chemical, magnetic and other basic sensors, environmental sensors, biosensors, swarms (smart dust), object tracking and identification systems. Through using one or several of these sensor types, the mechanism gains the capacity to "sense" the information input in the environment and interacts with the information field in the surrounding environment.

[61] Dudek, Gregory and Jenkin, Michael. *Computational Principles of Mobile Robotics* (New York: Cambridge University Press, 2000).

the environment.[62] In an active sensing system, input signals are generated by actuators, where the input is defined and known in advance. During the generation of input signals, direct interaction with the environment or the actuating agent is provided, which requires deliberate interaction of the sensors.[63] In order to allow for a direct interaction process, sensors that transmit and receive signals are mainly placed on the subject's body or the environment.[64]

In contrast to active sensing, passive sensing makes only use of sensors and does not need actuators to capture the information from the environment or the participant.[65] In passive sensing, information is captured without requiring a change in the behavior of the participant or in his/her conscious interaction with the environment.[66] Pressure sensitive floor mats, video tracking, infra-red sensors, temperature, proximity and ultra-sonic sensors are several types of passive sensors. Interacting with these sensors, the participants do not need to wear, attach or fix any apparatuses. Awareness by the user marks the main distinction between active and passive sensing. Therefore, passive sensing which does not necessitate the conscious interaction of the participant is considered not as invasive as active sensing. Since both of the systems have advantages and disadvantages, fusion of the two approaches is also proposed.

An example of this fusion is practiced in the *T-Garden* project, which is a responsive media environment. In the *T-Garden*, participants are equipped with

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[62] Ibid.

[63] Beilharz, Kirsty. "Responsive Sensate Environments: Past and Future Directions: Designing Space as an Interface with Socio-Spatial Information." In *11th International Conference on Computer Aided Architectural Design Futures*, Proceedings, 361-370. Austria, 2005.

[64] Ibid.

[65] Dudek and Jenkin, *Computational Principles of Mobile Robotics*.

[66] Beilharz, "Responsive Sensate Environments: Past and Future Directions: Designing Space as an Interface with Socio-Spatial Information."

sensors and tracking devices that enable the active participation of the participant in the interaction (figure 7). The participants can manipulate and mold the projected sound and video as they move and also can put on sound and dance with images in a tangible way to construct musical and visual worlds.[67] During the performance, the participants act in costumes outfitted with sensing, computing and processing devices. The participant equipped with all these instruments and sensors is left alone in the performance space before the experience starts so that s/he will have the chance to explore the types of interactions defined between his/her body and the responsive environment.[68] As the participants move and perform in the responsive environment the walls and floor appear to transform and respond to the participant.

Figure 7: Costumes outfitted with sensing, computing and processing devices used during the performance.

FoAM. http://www.f0.am/tgarden. [Accessed: January, 2011].

In responsive mechanisms making use of computer mediated appliances, the information gathered from the environment and/or participant is processed in

[67] Sha, Xin Wei. "Resistance Is Fertile: Gesture and Agency in the Field of Responsive Media." *Configurations.* Vol. 10 No. 3 (Fall 2002): 439-472.

[68] Sha, Xin Wei. "The TGarden Performance Research Project." *Modern Drama, Special Issue: Technology.* Vol. 48 No. 3 (Fall 2005): 585-608.

the control process according to the relations defined either simultaneously or in advance and the response of the mechanism is provided. Information detected through the sensors and sensing devices are analyzed and treated during this process and the real-time performance of the system is defined.[69] The computed performances and their corresponding configurations are actuated in real time through the actuators, which are commonly defined as "mechanical devices used to alter the state of a physical system or structure."[70] Consequently, with the use of actuators, responsive mechanisms act in real time and display the response of the system to the information gathered from the environment either in the same or a different medium. Acknowledgement of these processes with the help of emerging sensing and actuating technologies, either used separately or together, enable real-time and continuous data flow and help to define the responsiveness of the environment and the interaction between the mechanism and the participant.

2.2 Interactivity

The concept of interactivity in architecture and built environment is closely related with information technology and interconnected models of information. Practicing through these technologies and models facilitates simultaneous redefinition of the response and also the relations between the participants. Through the intrinsically interconnected model, it becomes possible to provide built environments and experiences in constant modification while responding to changes in the information content provided by the other party involved in the interaction process.

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[69] Leung, Wai-Lun Danny, Li, Zheng and Ayhan, Bülent. "Intelligent Space with Time Sensitive Applications." http://ieeexplore.ieee.org/iel5/10040/32215/01511209.pdf. [Accessed: March, 2011].

[70] d'Estrée Sterk, "Using Actuated Tensegrity Structures to Produce a Responsive Architecture."

In Kas Oosterhuis' definition of interactive architecture, the latter is not only responsive or adaptive to changing circumstances, but more importantly, it is based on the concept of bi-directional communication, which requires two active parties.[71] Therefore, the interactivity concept inherits the involvement of at least two parties in the definition of a reciprocal relationship; the participant and the interactive interface.[72] At this point the concept of interactivity can be differentiated from the concept of responsiveness, since an environment does not essentially require an interactive relationship with another party (participant) to be defined as responsive. Accordingly, it can be argued that each interactive environment or mechanism can be considered as also being responsive, whereas each responsive environment or mechanism may not be considered as interactive. The responsiveness provided through material properties can be regarded as an example of this differentiation, where the mechanism responds to the changes in the environment through its material properties without defining an interaction with a different party.

On the other hand, this bi-directional relationship either between different parties of built components that interact with each other or between the participant and the built components can be defined through the concept of interactivity.[73] Within the scope of this thesis, it is mainly concentrated on the

[71] Oosterhuis, Kas and Xia, Xin. *iA: No. 2 (Interactive Architecture) (*Episode Publishers, 2008).

[72] In the typical definition of interactivity, it involves the engagement of two parties one of which is defined as the user, the interacting agent or the interactor that interacts with the interface and triggers the relationship between them. However, throughout the thesis this party is referred to as the *participant* in line with Stroud Cornock and Ernest Edmonds's use of the term when describing an art system in their paper; *The Creative Process Where the Artist Is Amplified or Superseded by the Computer.* Cornock and Edmond, highlighting the function of the arts to stimulate a high degree of involvement of the viewer, introduce the term participant to replace the terms viewer and audience. They state that the participants may be treated as one of the elements of the dynamic situation and that an art work may be used to trigger the participant. Considering that the term participant evoke the active involvement of the human, it is prefered to refer to the user, interacting agent or interactor in the responsive environment as the participant.

[73] Oosterhuis and Xia, *iA: No. 2 (Interactive Architecture)*.

interaction defined between the participant and the built component, where each party responds to the other to define a responsive relationship.

The current understanding of interactivity is mainly built upon embedded computation that satisfies the adaptation of the proposed interface to the environment attaining the desire to meet changing circumstances and desires.[74] These circumstances and desires can be asserted to range from material to social, individual to environmental, psychological to physiological etc. In order to attain the intended adaptation between different parties of interaction, these environments propose new configurations and responses in real time mainly through complex and adaptive systems of embedded computation.[75] Through these systems, the interactive interfaces provide not only responsive and adaptive behaviors but also pro-active performances.[76]

Depended on a scripted code of design (software), these environments detect and scan the information content provided with the interaction process, calculate and process this new information input and produce their responsive behavior simultaneously. [77] The provided output can also be regarded as a new input to the environment that changes the current information content of the environment. Through this way, the interactive interface defines its relation with the environment and/or the participant. Therefore, these interactive environments inherit the definition of ever-changing states and behaviors, where parties are in communication with each other and propose new configurations in real time.

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[74] Fox, Michael and Kemp, Miles.*Interactive Architecture (*Princeton Architectural Press, 2009).

[75] Oosterhuis and Xia, *iA: No. 2 (Interactive Architecture)*.

[76] Ibid.

[77] Ibid.

Used to describe many devices and environments from software to mobile devices, textiles to furniture, the concept of interactivity is mainly dependent on a linear call-and-response relationship between the parties of interaction.[78] Despite the common interest in the active engagement of both parties in defining dynamic relations between the environment, participant, and the interface, the pre-programmed cycles of their interaction may be asserted to result in these call-and-response relationships.

An example of this conception is the *Muscle Re-configured* project, formerly exhibited at the Centre Pompidou in Paris, as part of the "*Architectures Non Standard*" exhibition in 2004, curated by Frédéric Migayrou and Zeynep Mennan. [79] The project aims to materialize a responsive environment through interacting with the participant in real time. The configured prototype is conceptualized as a 3D strip that responds to the occupants who engage in the interaction process (figure 8). The prototype responds to and materializes the interaction with the participant through its sensing (proximity and touch sensors), processing (scripting for real-time output) and actuating (fluidic muscles) components.[80]

During the interaction process, the proximity of people near the units is captured, where the captured information is processed through several

[78] Haque, Usman. "Distinguishing Concepts: Lexicons of Interactive Art and Architecture." *AD: 4dsocial: Interactive Design Environments*. Vol. 77 No. 4 (July 2007): 26.

[79] The prototype is an evolved version of the "Muscle" project developed by HRG and ONL for the *Nonstandard Architecture Exhibition* held in 2004 (Centre Pompidou, Paris). The 'Muscle' project was specific with its capacity to change shape by contracting and relaxing through its pneumatic muscles.

[80] Biloria, Nimish and Oosterhuis, Kas. "Envisioning the Responsive Milieu: An Investigation into Aspects of Ambient Intelligence, Human Machine Symbiosis and Ubiquitous Computing for Developing a Generic Real-time Interactive Spatial Prototype," in *10th International Conference on Computer Aided Architectural Design Research in Asia (CAADRIA),* Proceedings, 421-432. India, 2005.

interfaces and software.[81] Subsequent to the processing, the information gathered from the environment is re-routed into the environment and the muscle components are triggered.[82] Consequently, an initial curvature is provided on the surface of the strip that allows people to sit or lay on. After this first stage of interaction, the surface of the strip traces the information content of the interaction through sensing units of touch attached to it and that trigger the height and curvature of the strip.[83]

Figure 8: The finished prototype in the form of a real-time interactive spatial loop.

Source: Biloria, Nimish. "Spatializing Real Time Interactive Environments." in *1st International Conference on Tangible and Embedded Interaction,* Proceedings, 215-222. USA, 2007.

The strip is composed of three elements: responsive floor, ceiling and walls enriched with technological components such as actuators, sensors, air valves, PCI cards etc., linked physically together. Through these three elements, the spatial loop is defined that interacts with the participants and alters its current

[81] Biloria and Oosterhuis, "Envisioning the Responsive Milieu: An Investigation into Aspects of Ambient Intelligence, Human Machine Symbiosis and Ubiquitous Computing for Developing a Generic Real-time Interactive Spatial Prototype."

[82] Ibid.

[83] Oosterhuis, Kas and Xia, Xin. *iA: No. 1 (Interactive Architecture)* (Ram Distribution, 2007).

state in real time.[84] The responsive loop aims to transform the space into an ever-changing responsive organism through its interaction with the participant, where they exchange information and define a call-and-response interaction. Although the response of the interactive interface inherits the potential of affecting the participants' response and defines an ever-changing relationship, it is mainly a linear relationship that is proposed.

On the other hand, interactivity may go beyond defining varying configurations and spatial experiences in relation to the alterations in the interaction process, and define an interface that can respond to these alterations through different scenarios of information processing. This enables to alter the response of the interactive interface to the environment and/or the participant, and may in turn affect its response to the interface. Usman Haque defines this situation as a circular mutual relationship: According to Haque, a circular mutual relationship is "about affecting not just actual output (in response to input) but also about affecting the way that output is calculated."[85] It is a continuous relationship that is defined by Haque where the two parties of interaction define a continual and constructive information exchange.[86]

Another example that provides a responsive interaction environment is the *Ada* project, which is an experimental infrastructure constructed for the Swiss national exhibition Expo 2002.[87] *Ada* is conceived as a responsive organism that can interact and communicate with her visitors by using a language of light

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[84] Biloria, Nimish. "Spatializing Real Time Interactive Environments." in *1st International Conference on Tangible and Embedded Interaction,* Proceedings, 215-222. USA, 2007.

[85] Haque, "Distinguishing Concepts: Lexicons of Interactive Art and Architecture," *26.*

[86] Haque, Usman. "Architecture, Interactions, Systems." *AU: Arquitetura & Urbanismo,* No149, 2006.

[87] Eng, K., Mintz, M., Verschure, P.F.M.J. "Collective Human Behavior in Interactive Space." In *IEEE Conference on Robotics and Automation*, Proceedings, 2057-2062. Spain, 2005.

and sound (figure 9-10).[88] This project intends to question the ways of enhancing the quantitative understanding of collective human behavior in responsive environments and looks for ways of constructing active environments that can automatically influence human motion and experience.[89] In *Ada* project, the proposed interface takes into account the changes in the responses of the participants and provides different scenarios of interaction. Hence it is intended to define a mutual relationship, where each party of interaction is affected from others' response and ever-changing experience.

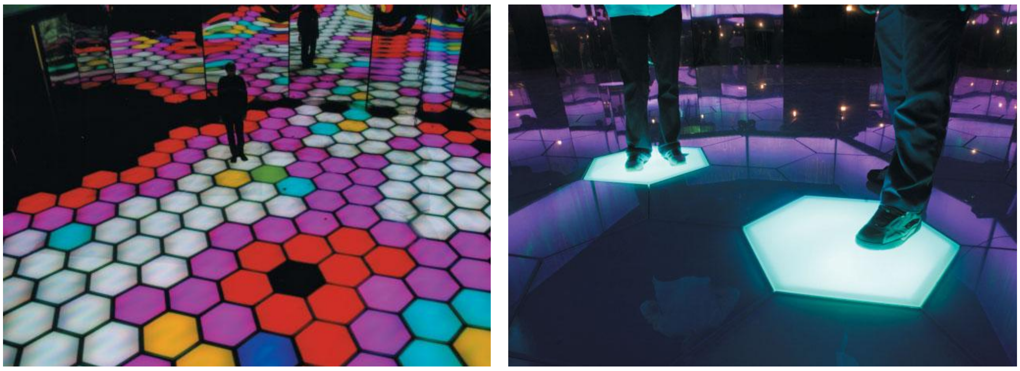

Figure 9: Participants interacting with the surfaces of Ada.

Source. Bullivant, Lucy. "ADA: The Intelligent Room." *AD: 4dspace: Interactive Architecture.* Vol. 75 No. 1 (January-February 2005): 87.

In *Ada*, the participants (visitors) are provided with an environment where their only sensory stimulation comes from the *Ada* itself and other participants.[90] *Ada* can communicate with the participants collectively via global lighting and

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[88] Eng, K., Baebler, A., Bernardet, U., Blanchard, M., Briska, A., Costa, M., Delbruck, T., Douglas, R., Hepp, K., Klein, D., Manzolli, J., Mintz, M., Netter, T., Roth, F., Wassermann, K., Whatley, A., Wittmann, A. and Verschure, P. "Ada: Buildings as Organisms." in *Game, Set, Match,* Proceedings, 33-44. Netherlands, 2003.

[89] Eng, Mintz, and Verschure, "Collective Human Behavior in Interactive Space."

[90] Eng, K., Baebler, A., Bernardet, U., Blanchard, M., Costa, M., Delbruck, T., Douglas, R.J., Hepp, K., Klein, D., Manzolli, J., Mintz, M., Roth, F., Rutishauser, U., Wassermann, K., Whatley, A.M., Wittmann, A., Wyss, R., and Verschure, P.F.M.J. "Ada – Intelligent Space: An artificial creature for the Swiss Expo.02." in *IEEE/RSJ International Conference on Robotics and Automation,* Proceedings, 4154-4159.Taipei, 2003.

background music.[91] In this project, it is intended to show that "human movement is predictive of key attitudes towards a space and other humans, and that subjects' behavior and attitudes are influenced by subtle modifications of environmental parameters."[92] In order to provide the necessary information for this argument, the project makes use of sensorial data, i.e. vision, audition, touch, and tries to locate the users in the performance area and identify the changes in the subjects' attitudes.

Figure 10: The main space of interaction in Ada project.

Source. Bullivant, Lucy. "ADA: The Intelligent Room." *AD: 4dspace: Interactive Architecture.* Vol. 75 No. 1 (January-February 2005): 86.

Made up of sensorial floors, walls and ceilings, the project makes use of a tracking system, a vision system and an audio system. According to the data, image, sound gathered from these systems, real-time responses are provided. [93] The underlying software and the system architecture behind this interaction scenario are composed of a set of interconnected, interdependent, simultaneously evolving internal processes that question "how can

[91] Ibid.

[92] Eng, Mintz, and Verschure, "Collective Human Behavior in Interactive Space."

[93] Eng et al., "Ada – Intelligent Space: An artificial creature for the Swiss Expo.02."

environments and their inhabitants adaptively influence each other's behavior in order to achieve common or complementary goals."[94]

The *Ada* project intends to influence the behavior of participants by learning to arrange particular types of cues and aims to provide for the continuity of interaction.[95] Compared to the *Muscle re-configured* project, it may be asserted that *Ada* provides a more adaptive interface, not only physically but also systematically and conceptually, that adapts to the responses of each party of interaction and influence the interaction scenarios in a mutual way.

2.3 Intelligence and Artificial Intelligence

Intelligence and studies in artificial intelligence gain importance in defining the responsiveness of the environment and are therefore to be considered an important facet of studies in the field of responsiveness. Although most responsive environments do not propose an intelligent behavior, they are fed by studies in artificial intelligence and the very concept of intelligence.

Defined basically as the ability to deal with cognitive complexity, intelligence is identified by Gottfredson as follows;

> "Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for

[94] Eng, K and Douglas, R J and Verschure, P. F. M. J. "An Interactive Space that Learns to Influence Human Behaviour." in *IEEE Transactions on Systems, Man, and Cybernetics*, Proceedings, 66-77. 2005.

[95] Ibid.

> comprehending our surroundings- "catching on", "making sense" of things, or "figuring out" what to do."[96]

Gottfredson's definition does not imply intelligence as an ability possessed only by humans. Rather it inherits some flexibility and does not specify whether it is someone or something that performs intelligence. Such a distinction is important when studies in artificial intelligence (AI) are considered.

AI is defined broadly as a field of study that "seeks to explain and emulate intelligent behavior in terms of computational processes."[97] There are many definitions of AI related with the researcher's field of interest, goal or method. While Patrick Henry Winston defines artificial intelligence as "the study of ideas that enable computers to be intelligent,"[98] Eugene Chamiak defines it as "the study of mental faculties through the use of computational models." [99] Peter Bock states that "artificial intelligence is the ability of a human-made machine to emulate or simulate human methods for the deductive and inductive acquisition and application of knowledge and reason," [100] whereas Margaret Boden states that "artificial intelligence is the science of making machines do things that would require intelligence if done by men." [101]

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[96] Gottfredson , Linda. "Mainstream Science on Intelligence." *The Wall Street Journal.* http://www.udel.edu/educ/gottfredson/reprints/1994WSJmainstream.pdf.[Accessed: March, 2011].

[97] Schalkoff, Robert J. *Artificial Intelligence: An Engineering Approach (*New York: McGraw-Hill, 1990), 2-3.

[98] Winston, Patrick Henry. *Artificial Intelligence* (Mass.: Addison-Wesley Publishing Company, 1984),1.

[99] Charniak, Eugene and McDermott, Drew. *Introduction to Artificial Intelligence* (Mass.: Addison-Wesley Publishing Company, 1985), 6.

[100] Bock, Peter, "The Emergence of Artificial Intelligence: Learning o Learn." *The AI Magazine*. Vol.6 No.3: (Fall 1985): 180-190.

[101] Boden, Margaret A. *Artificial Intelligence and Natural Man* (New York: Basic Books Inc., 1977), 4.

Despite this diversity of definitions, AI studies have a common concern for intelligent behavior in artifacts associated with human performances such as reasoning, optimization, knowledge, planning, learning, or perception.[102] Therefore, it may be asserted that AI studies mainly aim to attain the capacity to perform functions, which are mostly associated with human intelligence.

Emphasizing either the importance of intelligence or that of the computing devices, it is possible to identify two main streams within the field: strong and weak AI. The difference between these two streams lies in distinct assumptions regarding the abilities of thinking machines.[103] In the conception of strong AI it is considered that it is possible to make machines that perform the thinking ability of humans. [104] On the other hand, in weak AI conception, it is believed that machines can only imitate certain traits of human intelligence.[105]

Since the studies in AI deal mainly with human capabilities, they stand as a major influence on certain fields of study such as biology, computer science, art, psychology, mathematics, etc. Related with the studies in AI, Intelligent Building/Environment concepts are introduced, which may be asserted to initiate an important shift in architecture. Taking into consideration the definitions of intelligence and AI, the Intelligent Environments can be identified as representing high levels of awareness and communication among systems. Through the consciousness of the environment, it becomes possible to control the relationships between different parties and accomplish performance

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[102] Russell, Stuart J. and Norvig, Peter. *Artificial Intelligence: A Modern Approach* (N.J.: Upper Saddle River, 2003).

[103] Floridi, Luciano. *Philosophy and Computing: An Introduction* (London and New York: Routledge. 1999).

[104] Ibid.

[105] Ibid.

criteria such as productivity, efficiency, comfort, or sustainability.[106] Therefore, the intelligent building concept can be associated with the ability to control and manage the building's systems in order to respond to the desires and needs of the participant by means of the intelligence of the system/environment.[107]

Although there exists various definitions of an intelligent building and what makes a building intelligent, many of these definitions share a common ground; they all aim to satisfy increased environmental comfort, energy optimization, security, and automated building maintenance procedures.[108] Jong Jin Kim defines an intelligent building as one that maximizes efficiency while allowing for effective management with minimum costs; an intelligent building optimizes structure, systems, services and management to help business owners, property managers and occupants realize their goals in cost, comfort, convenience, safety, long term flexibility and marketability.[109] On the other hand, Atkin defines an intelligent building as a "building that knows what is happening inside it and outside it and can decide the most effective way to create the right environment for users on time."[110] What differentiates Atkin's definition is mainly the ability of an intelligent building to know, decide and respond. The ability to "know" covers the collection of information and also

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[106] Sherbini, Khaled and Krawczyk, Robert. "Overview of Intelligent Architecture." In *eDesign in Architecture: ASCAAD's First International Conference on Computer Aided Architectural Design*, Proceedings, Saudi Arabia, 2004.

[107] Ibid.

[108] Anshuman, Sachin. "Responsiveness and Social Expression; Seeking Human Embodiment in Intelligent Façades." in *Annual Conference of the Association for Computer Aided Design In Architecture*. Proceedings, 13-16. Savannah (Georgia), 2005.

[109] Kim, Jong Jin. "Intelligent Building Technologies; A Case of Japanese Buildings." *The Journal of Architecture*. Vol. 1 No. 2 (Summer 1996): 48-164.

[110] Atkin, Brian. "Progress Towards Intelligent Buildings." In *Intelligent Buildings (*New York: John Wiley & Sons, 1988).

awareness of the information in Atkin's definition.[111]Along with that, "decision-making" corresponds to responding to the received information and adapting to the newly defined conditions.[112]

Therefore, an intelligent building can be defined to have the ability to respond to the changes in the environment and in user needs, while processing the information received from the environment through various ways (real-time detectors, internal backups etc.) and having the ability to learn and decide.[113] Learning and decision-making abilities can be considered as the key features that distinguish intelligent buildings from others. Taking into consideration these aspects and potentials, it can be asserted that AI and the concept of intelligent buildings/environments gain importance and affect the research carried on responsiveness since they impinge on the definition of responsiveness and responsive environments.

2.4 Developments Triggering Research on Responsive Environments

2.4.1 History and Development of Cybernetics

Cybernetics, the field of control and communication theories, is considered as one of the research fields that directly or indirectly influence the conception of responsiveness and the studies on responsive environments. Concerned mainly with how the system functions, cybernetics studies how the system operates the information derived from the environment and controls the actions in order to satisfy the goals.[114] Therefore, the thesis provides an overview of the

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[111] Sherbini and Krawczyk, "Overview of Intelligent Architecture."

[112] Ibid.

[113] Ibid.

[114] Heylighen, Francis and Joslyn, Cliff. "Cybernetics and Second-Order Cybernetics." *Encyclopedia of Physical Science & Technology* (New York: Academic Press, 2001), 155-170.

theoretical work of a number of people working on responsiveness provided by computer technology and control processes mainly after the 1960s. The early ideas rooted in this field were closely related with cybernetics. The studies on cybernetics affected the studies on the built environment and attempts for providing responsive environments.

The field emerged in the 1940s when a group of mathematicians, engineers, physiologists, sociologists, and philosophers put forward cybernetics as a new research field structured on the idea of uniting control and communication mechanisms in living organisms and those in complex self-regulating machines. In particular, the series of interdisciplinary meetings called Macy Conferences on Cybernetics, which were held between 1944 and 1953 and hosted by the Josiah Macy Jr. Foundation, affected the definition of cybernetics as a specific field.[115] These conference series brought together a number of intellectuals and scientists from different disciplines, including Norbert Wiener, John von Neumann, Warren McCulloch, Claude Shannon, Heinz von Foerster, W. Ross Ashby, Gregory Bateson and Margaret Mead and broadened the research field of cybernetics to encompass minds and bodies besides machines and animals.[116]

One of the significant figures in this field, the mathematician Norbert Wiener's pioneering efforts is asserted to establish the foundations for the theory of the behavior of unstable systems known as cybernetics.[117] Named after the Greek word "cyber," meaning "rudder" or "to steer", Wiener defines cybernetics as the science of communication and control in machines and living organisms, and states that machine, animal, and human communication are not essentially

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[115] Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago, Ill.: University of Chicago Press, 1999).

[116] Ibid.

[117] Wiener, Norbert. *Cybernetics: Or Control and Communication in the Animal and the Machine* (Cambridge: MIT Press, 1961).

different from one another.[118] Wiener's theory of organization and control relations in systems is inspired by mechanical control systems and the development of a mathematical theory of communication.[119] According to Wiener the cybernetic system "continuously adjusts itself in response to unpredictable conditions by anticipating future behavioral patterns on the basis of feedback information from prior actions."[120] In any concept of system and hence in cybernetic systems, the system is composed of a feedback loop that carries information to the controller related with the consequences of the actions it had performed.[121] Accordingly, the feedback that produces iterations through continuous execution of a process or function until the specified or desired condition is met can be considered as the crucial feature of cybernetic systems.

One of the key figures in this period is Gordon Pask, who was one of the early cyberneticians in the 1960s and had a tremendous influence on the concept of responsiveness and responsive environments. Pask collaborated with a number of architects in the '70s and '80s and proposed a change in the conception of built environment and the way these environments are produced.

Nicholas Negroponte, the founder of the MIT Media Lab in 1985 (date, if you know it), is among the first architects proposing to make use of computer power to increase the performance of built environments. In his book *Soft Architecture Machines*, Negroponte identifies his ambition to define buildings which are assisted, augmented and replicated by a computer.[122] The term

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[118] Wiener, Norbert. "Cybernetics in History." *The Human Use of Human Beings: Cybernetics and Society* (Boston: Houghton Mifflin. 1954).

[119] Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine.*

[120] Ibid.

[121] Ibid.

[122] Negroponte, *Soft Architecture Machines*.

‘responsive architecture’ was first used by Negroponte in the late nineteen sixties, where he proposed that responsive architectures with the integration of computing power will lead to structures and environments acting as an evolving mechanism. [123]

Another important figure in the evolution of the concept of responsiveness is Charles Eastman, who developed the concept of “adaptive-conditional architecture” in 1972.[124] The model of “adaptive-conditional architecture” proposes the use of feedback from spaces and users to control architecture and provide the self-adjustment of the environment or system.[125] Hence, computerized/programmed systems could control buildings’ responses and consequently respond to the needs of the user.[126] Eastman used the analogy of a thermostat to describe the essential components of these computerized systems which are the common features used in defining responsiveness. In this thermostat example it is proposed that the sensors would detect the changes in the temperature of the environment while the control mechanisms would interpret the information transmitted from the sensors. Subsequently, the response of the control mechanism would be send back to the environment and change the temperature of the environment according to the information produced at the controller. Consequently the feedback gathered from the environment would be processed and conditional adaptation attained.

Explanation of feedback theories and goal directed behavior in terms of control and information are considered to be the fundamental contribution of cybernetics during the 1940's and 1950's, which also influenced several

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[123] Ibid.

[124] Eastman, C. “Adaptive-Conditional Architecture.” In *Design Research Society’s Conference,* Proceedings, 51-57. Manchester, 1971.

[125] Ibid.

[126] Ibid.

research fields such as control theory, computer science, information theory, artificial intelligence, cognitive science, computer modeling and simulation science. In recent years, the field of cybernetics has been regarded as divided into two periods, which are first order cybernetics that covers a period from late 1940s until about mid 1970s and second order cybernetics that covers the period from mid 1970s to the present.

2.4.1.1 First Order and Second Order Cybernetics

First order cybernetics provides a view of a system where the participant is placed outside the system that is observed.[127] In this view, the participants are considered disconnected from the system that is observed.[128] In first order cybernetics, the focus is placed on the observed system, and the participant is defined as observing the system that exists out there. Therefore, in this view of cybernetics it is possible to define the system as independent from the participant observing it. However, this view resulted in uncertainty about how to figure out the relation between the participants being placed into what they observe. The studies on this confused situation are named as higher order of cybernetics, cybernetics of cybernetics or second order cybernetics.[129]

After the common use of computers in many control systems throughout the 1960's and 70's and the advances in information technologies, the studies in cybernetics were commonly associated with computers. Especially the feedback mechanisms employed in contemporary control devices and servomechanisms were related with the feedback mechanisms of cybernetic

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[127] Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics,* 9.

[128] von Foerster, Heinz. *The Cybernetics of Cybernetics* (Minneapolis: FutureSystems Inc. 1995).

[129] Ibid.

systems.[130] With these fascinations, cybernetics has been interested in the similarities between autonomous, living systems and machines, guided by the system designer who determines what the system will do. [131]

However, subsequent to the use of computers in control engineering and computer science disciplines in the early 1970s, some cyberneticists felt the need to depart from mechanistic approaches and rather emphasize the autonomy, self-organization, cognition, and the role of the observer in modeling a system. [132] In this departure, which became to be known as second-order cybernetics, the system is considered as an agent in its own right, interacting with another agent; the observer.[133] This second wave of cybernetics is commonly associated with the works of Heinz von Foerster, Humberto Maturana and Gordon Pask.

In the second wave, the observer is also defined as a cybernetic system, trying to construct a model of another cybernetic system and therefore this second wave is referred to as the "cybernetics of cybernetics." The cybernetic system is envisioned as an agent that is active and interacting with other agents, hence denying any separation between the observer and the observed participants. [134] Conversely, in the first-order cybernetics the system is considered as passive and can be freely observed, manipulated, and taken apart. This second wave of cybernetics displaces the focus placed on the separation of participant from the observed agent and is primarily concerned with the presence of the

[130] Wiener, Norbert. *Cybernetics: Or Control and Communication in the Animal and the Machine.*

[131] Ashby, W. Ross. *An Introduction to Cybernetics* (London: Methuen & Co., 1964).

[132] Heylighen and Joslyn, “Cybernetics and Second-Order Cybernetics.”

[133] Ashby, *An Introduction to Cybernetics*.

[134] von Foerster, *The Cybernetics of Cybernetics.*

participant.[135] The participant, considered as a cybernetic system, also constructs another cybernetic system composed of agents that are observing and are observed.

Cedric Price extended the discussion of cybernetics in his works where he attempted to explore the use of technology to have unprecedented control over the environment.[136] This experience is stated to result in an environment which could be responsive to participants' needs and the conditions of the environment.[137] With this intention, many of his unbuilt projects aimed to define indeterminate, flexible and responsive environments to the changing needs of users and their times.[138] Two most influential projects are the *Fun Palace,* which aimed to sustain the indeterminacy and continuity of interaction and the *Generator* project which was an important investigation into AI with the ability to learn from experience.

One of the essential examples of an adaptive and responsive environment proposal is the *Fun Palace* by Cedric Price, designed in 1961 in England (figure 11-12).[139] Considered to be an important contribution to the human-machine interaction and engagement of adaptability through flow of decisions and interactions, the *Fun Palace* promotes human participation and the transformation of the built environment.[140] The Fun Palace, which was never

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[135] Ashby, *An Introduction to Cybernetics*.

[136] Diniz, Nancy, Cesar Branco, Miguel Sales Dias and Alasdair Turner. "Morphosis: A Responsive Membrane," in *12th International Conference on Computer Aided Architectural Design Futures.* Proceedings, 489-498. Australia, 2007.

[137] Ibid.

[138] Negroponte, *Soft Architecture Machines*.

[139] Mathews, Stanley. "The Fun Palace as Virtual Architecture Cedric Price and the Practices of Indeterminacy." *Journal of Architectural Education.* Vol.59 No.3 (February 2006): 39-48.

[140] Wilken, Rowan. "Calculated Uncertainty: Computers, Chance Encounters, and 'Community' in the Work of Cedric Price." *Accidental Environments.*No. 14, 2007. http://transformationsjournal.org/journal/issue_14/article_04.shtml. [Accessed: March, 2011].

built, is “a proposal for a center that marries communication technologies and standard building components to produce a machine capable of adapting to the visitor’s needs and desires."[141] Together with Joan Littlewood, who is the director and founder of the Theatre Workshop in East London, Price suggested a ‘laboratory of fun.’[142] Littlewood stresses that “the essence of the place will be its informality: nothing is obligatory, anything goes.”[143]

Defined as a deliberate experiment, the project intends to attain a “temporary, multiprogrammed [and reprogrammable] twenty-four-hour entertainment center that marries communications technologies and standard building components to produce a machine capable of adapting to the users’ needs and desires.”[144] The users can define their own spaces with various sizes, shapes and lighting qualities in the unstructured and free environment of the Fun Palace that reprograms and reconfigures itself according to the choices of users.[145]

The interpretation of the idea of fun by Cedric Price is put forth by Royston Landau, who points out that; “the idea of *fun* was not interpreted as passive entertainment as in the *amuse-me* ethic later to be adopted in the Walt Disney pleasure grounds,” rather, “it would be *fun* if the visitor could be stimulated or

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141 Lobsinger, Mary Lou. “Cedric Price: An Architecture of Performance.” *Daidalos.* Vol. 74 (2000): 22-29.

142 Mathews, “The Fun Palace as Virtual Architecture Cedric Price and the Practices of Indeterminacy.”

143 Littlewood, Joan. “A Laboratory of Fun.” *New Scientist.* Vol. 22 No. 391 (May 1964): 432.

144 Lobsinger, Mary Lou. “Cedric Price: An Architecture of Performance.” *Daidalos.* Vol. 74 (2000): 24.

145 Mathews, “The Fun Palace as Virtual Architecture Cedric Price and the Practices of Indeterminacy.”

informed, could react or interact, but if none of these suited, had the freedom to withdraw”.[146]

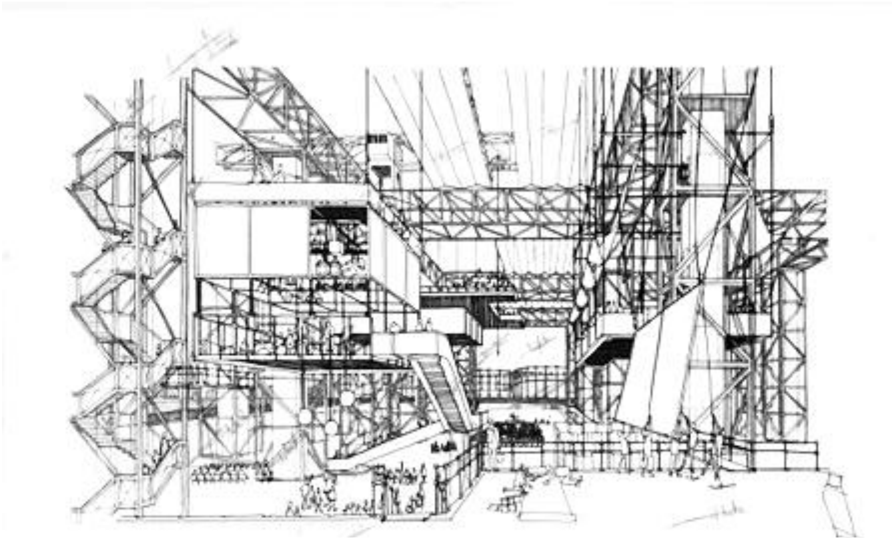

Figure 11: Cedric Price’s drawing of the interior of the Fun Palace.

Source: Mathews, Stanley. “The Fun Palace as Virtual Architecture Cedric Price and the Practices of Indeterminacy.” *Journal of Architectural Education.* Vol.59 No.3 (February 2006): 39-48.

In order to interpret Littlewood’s emphasis on the flexibility of the program through the architectural configuration of the structure, Price proposes an unenclosed steel frame structure with reconfigurable internal spaces, which “on the one hand, challenge the participants’ mental and physical dexterity and, on the other, allow for a flow of space and time, in which passive and active pleasure is provoked.”[147]

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[146] Landau, Royston. “A Philosophy of Enabling.” *Cedric Price, Works II* (London: Architectural Association, 1984), 11.

[147] Littlewood, “A Laboratory of Fun,” 433.

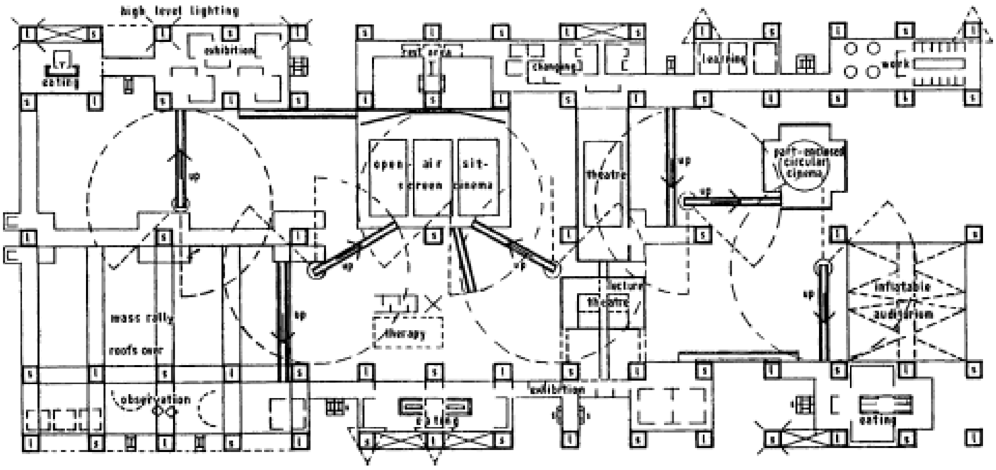

Figure 12: The Fun Palace floor plan, final version, showing moveable walkways and escalators.

Source: Price, Cedric. *The Square Book*. Chicester, West Sussex: Wiley-Academy, 2003.

The rearrangement of the steel structure is to be supplied by a gantry crane that spans the entire structure, which is composed of pre-fabricated walls, platforms, floors, stairs, and ceiling modules.[148] The cranes can move and reassemble the parts according to the changes in the needs or choices of the users. Through this way, the structure allows for different spatial arrangements, of which configuration and position can be adjusted according to the changing needs of the users. Considering every part of the structure as a variable, Price states that the form and the structure of the *Fun Palace* can be assembled, moved, re-arranged and scrapped continuously.[149]

This laboratory also aimed to embrace unpredictability and chance in its conception and performance in order to give the desired enthusiasm and

[148] Wilken, "Calculated Uncertainty: Computers, Chance Encounters, and 'Community' in the Work of Cedric Price."

[149] Littlewood, "A Laboratory of Fun," 433.

excitement to its users.[150] The results are available only through choices and trials. The unpredictability of the performance was in fact a designed and predicted outcome of the system by the designers, in order to attain the desired involvement. Mark Wigley, underlining the potential of the unpredictability of the system, defines *Fun Palace* as "a celebration of the temporary, a huge machine dedicated to the transformative power of the ephemeral and unpredictable flow of creative forces." [151]

Through the use of technological advances, Price aimed to better respond to the different spatial requirements of the users that change in time and allow for a free operative area for them, which initiates new spatial experiences for the users.[152] The changeable program and form of the project that considers the desires, choices and needs of the users inherit manifestations of the current paradigms of the time such as cybernetics, unstable and indeterminate systems and game theory.[153] As a consequence of this correlation, Price was regarded as the first architect to establish the connections and the reflections of these theories through an architectural model.[154]

With these potentials, the *Fun Palace* can be considered to be one of the initial examples of responsive architecture making use of computational approaches and algorithmic thinking. It is also possible to trace the impacts of algorithmic

[150] Wigley, Mark. "Exhibition: Cedric Price - The Fun Palace," Curatorial Statement, Columbia University: Arthur Ross Architecture Gallery, Buell Hall, September 19, 2005. http://www.arch.columbia.edu/gsap/54880. [Accessed: March, 2010].

[151] Ibid.

[152] Mathews, "The Fun Palace as Virtual Architecture Cedric Price and the Practices of Indeterminacy."

[153] Crinson, Mark. "In the Bowels of the Fun Palace." *Mute Magazine*, 2008. http://www.metamute.org/en/html2pdf/view/11006A. [Accessed: March, 2011].

[154] Mathews, "The Fun Palace as Virtual Architecture Cedric Price and the Practices of Indeterminacy."

thinking, use of computer technology and also the desire to open up new insights to the participant in Price's *Generator* project.

Cedric Price planned the *Generator* project, which is also an unbuilt example, for Gilman Paper Corporation in Florida in collaboration with John and Julia Frazer between 1976 and 1979.[155] The project aimed to accommodate facilities like dance, theater, and exhibition and make the visitors and users actively participate in the performances.[156] Price's main argument was to propose a reconfigurable, modular and responsive arrangement by the use of technological advances in computation and studies on AI (figure 13).[157] In order to satisfy this goal, Price used an orthogonal grid to organize the site and in reference to this grid, cubical module enclosures, infill components, screening posts, decks and circulation components are placed with mobile cranes (figure 14).[158] Although Price provides possible arrangements of these components for communication with the participants, his aim is to facilitate change and diversification through the co-operative involvement of the users in the arrangement of the components.[159]

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155 Frazer, John. "The Co-operative Evolution of Buildings and Cities." in *CoBuild '98, The First International Workshop on Cooperative Buildings, Integrating Information, Organization, and Architecture*. Proceedings, 130-141. London, 1998.

156 MoMA. http://www.moma.org/collection/browse_results.php?criteria=O% 3AAD%3AE% 3A7986&page_number=4&template_id=1&sort_order=1. [Accessed: May, 2011].

157 Furtado, Gonçalo M.. "Cedric Price's Generator and the Frazers' Systems Research." *Technoetic Arts: A Journal of Speculative Research.* Vol.6 No.1 (March 2008): 55-72.

158 Ibid.

159 Ibid.

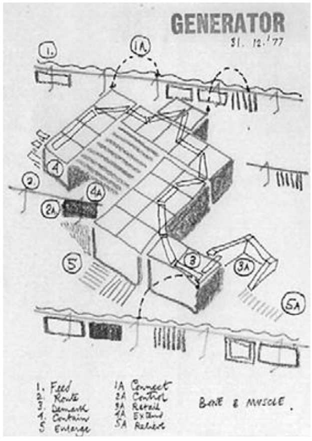

Figure 13 (Left): A model of a part of the Generator project.
Source: Frazer, John. “Computing Without Computers.” *AD: The 1970s is Here and Now.* Vol. 75.No. 2 (March-April 2005): 34-43.

Figure 14 (Right): Cedric Price’s sketch for the Generator project.
Source: Price, Cedric. *The Square Book*. Chicester, West Sussex: Wiley-Academy, 2003.

In order to attain the desired diversification and flexibility of the system, a responsive environment that makes use of computer technology has been designed both conceptually and physically. To develop the program that will suggest new arrangements of the system in response to the changing needs and interactions, Price invited John and Julia Frazer to participate in the design of the *Generator*.[160] Price communicated his intentions to Frazer through a letter where he stated that: ‘The whole intention of the project is to create architecture sufficiently responsive to the making of a change of mind constructively pleasurable.”[161] His clear intention of a responsive environment would be enabled via a computer program embedded in the electronic devices in each component of the system such as foundation pads, cranes, and screens.[162] By this way, the site would act as “a gigantic reconfigurable array processor, where the configuration of the processor was directly related to the

[160] Ibid.

[161] Ibid.

[162] Frazer, “The Co-operative Evolution of Buildings and Cities.”

configuration it was modeling."[163] The embedded sensors would trigger one or more of the four different computer programs designed according to different scenarios demonstrating its potential for a responsive, evolving, and collaborative environment.[164]

Of the different scenarios, the most interesting is the one related with the boredom factor. Since Price and Frazer were worried about the possibility that the systems' adaptable potential might not be used enough by the users, it was proposed that the system would suggest new challenges for the users when it is bored of monotony.[165] Frazer in his letter to Price explained about this boredom factor as:

> "[. . .] an extension [. . .] to generate unsolicited plans, improvements and modifications in response to users' comments, records of activities, or even by building in a boredom concept so that the site starts to make proposals about rearrangements of itself if no changes are made. The program could be heuristic and improve its own strategies for site organization on the basis of experience and feedback of user response."[166]

Therefore, the *Generator* proposed the capacity to learn and respond appropriately to the changing conditions and responses of the user. With these qualities, the *Generator* project is acknowledged to be one of the first proposals of a built environment, which learns from experience and responds to different impulses. This project, together with the *Fun Palace* proposal can be regarded as an important benchmark in the historical progress of utilizing the concept of responsiveness in the design of built environments.

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[163] Ibid.

[164] Ibid.

[165] Ibid.

[166] Furtado, "Cedric Price's Generator and the Frazers' Systems Research."

Highly influenced by studies on cybernetics and cyberneticians such as Norbert Wiener, John von Neumann and Gordon Pask during the 1960's and 1970's, architects were encouraged to think of buildings as feedback systems and tried to establish a relation between the human activity and the definition of the environment.[167] In this redefinition of the environment, architects also dealt with the relation between the human and the machine and tried to attain their continuous interaction and fusion. Although these studies laid the grounds for the explorations on responsiveness in the contemporary works, some of which are analyzed throughout this thesis, they can be criticized for providing only a one-way relationship and not a reciprocal one. However, some of them also intended to attain a bidirectional relationship and provide for a continuous responsiveness of the environment as a consequence of this relationship. One such example is the *Musicolor Machine*.

The *MusiColour Machine*, constructed in 1953, was designed by Gordon Pask as a performance system reacting to the auditory input from the human performer in a concert (figure 15-16).[168] Pask, aimed to include the participants in an interactive experience, where he assumed that the creative-productive role of the participant in interaction with such environments should be welcomed.[169] Pask reformulated cybernetics to propose an active cooperation of the system with the observers and participants.[170] The *MusiColour Machine* is an example of second-order cybernetics where the observer directly or indirectly participates in the construction and performance of the system.

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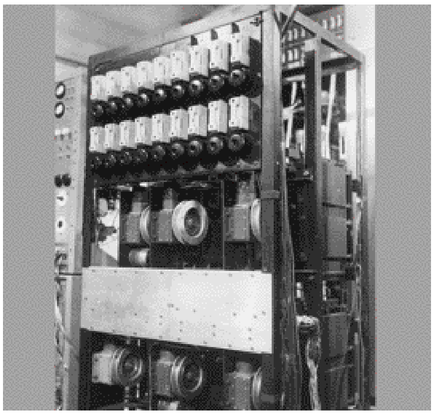
[167] Diniz et al., "Morphosis: A Responsive Membrane."

[168] Haque, Usman. "The Architectural Relevance of Gordon Pask." *AD: 4dsocial: Interactive Design Environments.* Vol. 77 No. 4 (July 2007): 54-61.

[169] Pask, Gordon. "Musicolour." *The Scientist Speculates. An Anthology of Partly-Baked Ideas*. Eds. Good I.J. New York: Basic Books (1962): 135-137.

[170] Heylighen and Joslyn, "Cybernetics and Second-Order Cybernetics."



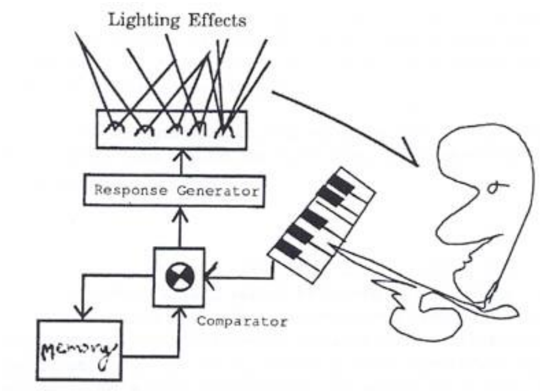


Figure 15 (Left): Control system of MusiColour Machine.
Source: Haque, Usman. "The Architectural Relevance of Gordon Pask." *AD: 4dsocial: Interactive Design Environments.* Vol. 77 No. 4 (July 2007): 54-61.

Figure 16 (Right): Diagram of a typical MusiColour system.
Source: Pask, Gordon. "A Comment, A Case History and a Plan." *Cybernetics, Art and Ideas*. London: Studio Vista,1971.

In the *MusiColour*, where Pask aimed to question whether a machine could learn the relations between sounds and visual patterns and implicitly enhance the performance itself, the colored light outputs act like another performer and actively participate in the performance.[171] The machine senses the sound produced by the performers and regards it as input from the environment.[172] Processing these inputs, the machine responds to the environment and the performers with lights in different colors flashed with different rhythms.[173] However, if the machine recognizes that it responds in the same manner for a specific period of time, it gets bored and changes the flashing-pattern. In doing so, the behavior of the *Musicolour* is altered and the outputs are re-defined.[174] It is assumed that, these alterations in the flashing pattern stimulate the

[171] Pask, "Musicolour.".

[172] Glanville, Ranulph. "And He was Magic." *Kybernetes.* Vol.30 No. 5/6 (2001): 652-672.

[173] Ibid.

[174] Ibid.

performers with strange and unexpected experiences, which may encourage them to change the way they perform. [175]

In addition, if the rhythm and the inputs gathered from the environment are too continuous, or the frequency range is too consistent, the machine gets bored again and searches for other frequency ranges. It only responds to the performance when it traces those desired frequency ranges or a change in the inputs provided by the performer.[176] Therefore, through responding to a certain frequency range until it gets bored and searching for other possibilities for different interactions or rearranging and changing its flashing-patterns for increasing the stimulation, the *MusiColour* is regarded as an on-stage participant for the performance.[177] This participation between the machine and the performer is intentionally sought after by Pask in order to attain the desired condition for the machine to learn, re-arrange itself and enhance the interaction. Pask states that:

> The performer trained the machine and it played a game with him. In this sense, the system acted as an extension of the performer with which he could co-operate to achieve effects that he could not achieve on his own. Consequently, the learning mechanism was extended and the machine itself became reformulated as a game player capable of habituating at several levels to the performer's gambits.'' [178]

The synergetic correlation provided in this project increases the continuity of interaction, where both the machine and the participant learn from the interaction and train each other. In second order cybernetics, the cybernetic system is constructed on the experiences and interpretations of the participant,

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[175] Pask, "Musicolour."

[176] Haque, "The Architectural Relevance of Gordon Pask."

[177] Ibid.

[178] Pask, Gordon. "A Comment, A Case History and a Plan." *Cybernetics, Art and Ideas* (London: Studio Vista,1971).

where the background and behavior of the participant challenges the definition of the system.[179] The participant's interpretation of the system and the relations defined between the participant, the environment and the machine are considered as the products of his/her background. His/her experiences and interpretations affect the understanding of the processes, where various agents are in cooperation.[180] In this complex organization, the participant can observe himself/herself as an observer of the system but cannot leave himself/herself out of the system.[181]

2.4.1.2 Cybernetic Machines

In cybernetics, a machine is defined as a system capable of performing actions to accomplish a certain goal according to some defined rules and regulations, whereas a cybernetic system is considered as a self-steering system.[182] The essential difference between a cybernetic machine and a cybernetic system occurs when the cybernetic system is considered as a living organism, since a living organism can be considered as being more open-ended in accomplishing its goals and can perform a higher degree of consciousness particularly when human beings are considered. [183] After receiving the information, the cybernetic system processes that information, reacts to it, measures its outcomes, and aims to accomplish its goal.

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[179] Haslebo, Gitte and Nielsen, Kit Sanne. "Key Concepts in Systemic Thinking." *Systems and Meaning: Consulting in Organizations (*London: Karnac Books, 2000).

[180] Ibid.

[181] Ibid.

[182] Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine.*

[183] Ibid.

A cybernetic machine, on the other hand, operates within rather predetermined parameters and does not manipulate the process.[184] Cybernetic machines act as a part of the process but are controlled by the system or the process. Although cybernetic machines are controlled by other machines, cybernetic systems can control themselves and do not necessitate other control mechanisms.[185] The common feature of cybernetic machines and cybernetic systems is that they both govern themselves through self-re-iteration, feedback, and self-propulsion.[186]

There also exists a distinction between the machine conceptions of first-order cybernetics and second-order cybernetics, where the machines of second-order cybernetics enable more flexibility and adaptability. Whereas machines of first-order cybernetics are characterized by determined function and task specificity, the information-controlled machines of second-order cybernetics can be altered simply by changing the information feedback rather than changing the entire configuration since they offer more flexible configurations.[187]

Although, it is possible to identify different definitions and classifications of machines in the field of cybernetics taking into consideration these distinctions, Wiener describes two types of machines: simple and complex. According to Wiener, a simple machine is a machine that cannot resist a change or disorganization within a system.[188] On the other hand, a complex machine is defined as making use of adaptive responses to maintain control in the environment.[189] Wiener identifies complex machines as cybernetic machines

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[184] Ibid.

[185] Ibid.

[186] Ibid.

[187] Ibid.

[188] Wiener, "Cybernetics in History."

[189] Ibid.

despite their passive role in manipulating the process.[190] Although the complex machines defined by Wiener or the machines offered by second-order cybernetics inherit the potential of altering the feedback loops of the process and provide more flexible configurations, they are still not responsive to the mutating conditions during the process and strongly depend on predetermined laws and principles. Therefore, despite their more indeterminate structures compared to the machines of first-order cybernetics, machines of second-order cybernetics and cybernetic systems can even then be criticized, since they are not responsive to the possible contradictions during the interaction processes and do not redefine their laws in relation to the information input from the environment or the human.

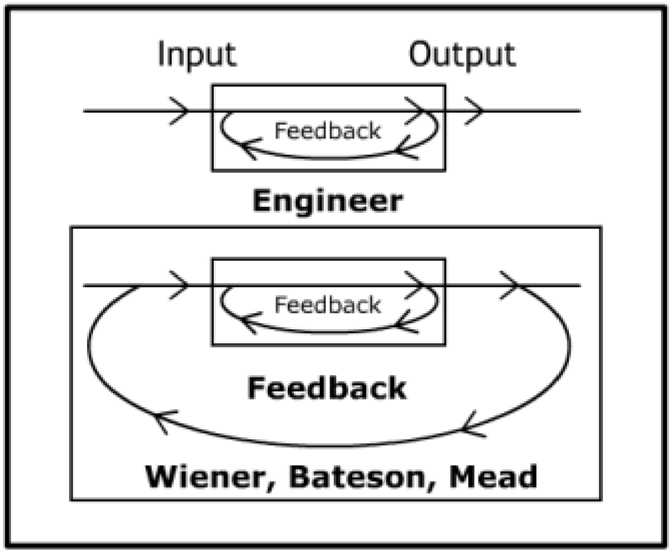

Figure 17: The diagram provided by Gregory Bateson and Margaret Mead in an interview in 1973 that compares the first and second-order cybernetics with this diagram and emphasize the definition of a possibly participant observer in the second case.

Source: Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics.* Chicago, Ill.: University of Chicago Press, 1999.

As an attempt at defining the adaptability of the machine to the changing conditions, Wiener refers to living organisms and provides new conceptions for

[190] Ibid.

the relationship between the human and the machine. Despite the common reference of cybernetics to computers and information technology, Wiener highlights the model of natural processes that allow all living entities to respond intelligently to the consequences of their own output and actively respond to and maintain the conditions of life. He defines the research field of cybernetics not only in reference to computers and information technologies but also took into consideration several properties of living organisms, especially those of human beings.[191] Referring to the metabolic feedback systems, which enable living organisms to maintain the steady state even in unstable environmental conditions, Wiener tries to find references to the idea of responsiveness from different domains. [192]

Accordingly, studies in cybernetics enabled to combine the concepts from different fields and served as a medium of exchange between different research fields. The cyberneticians took concepts of memory, homeostasis from physiological and psychological studies and combined them with the studies on machines and physiologists, where they proposed the application of concepts of information, programming, and feedback to living organisms.[193] In consequence of these interdisciplinary studies, new metaphors are provided leading to new conceptions of human-machine relationships, where the body is considered as a servomechanism, the organism as an entropy-reducing machine, the brain is conceptualized as a digital computer and communication as the transmission of information or thinking is associated with computation.[194]

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[191] Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine.*

[192] Ibid.

[193] Gerovitch, Slava. “Love-Hate for Man-Machine Metaphors in Soviet Physiology: From Pavlov to Physiological Cybernetics." *Science in Context*. Vol. 15 No. 2 (2002): 339-374.

[194] Ibid.

In the light of such concepts and studies, the border between machines and living organisms tends to blur, where the approaches offered by cybernetics enable to relate and interpret machines in different contexts. In this context, it becomes possible to borrow and use concepts from different disciplines and even define machines in biological terms or living organisms in terms of machines, leading to significant shifts in their definitions and positions. In this thesis study, it is asserted that the co-existence of machines and humans in responsive environments can provide for new interpretations of the relationship between the human and the machine. These discussions are elaborated in the third chapter.

2.4.2 Ubiquitous Computing

Another development that gives impetus to studies on responsiveness and responsive environments is ubiquitous computing. Ubiquitous computing is proposed as a human-computer interaction (HCI) model that puts forward the integration of information processing tasks into everyday objects and activities.[195] In ubiquitous computing, the environment is equipped with mechanisms and devices that give the environment the ability to respond to the human without distracting the activities, perception or comfort of the human.[196] Mark Weiser, who is considered as one of the key figures in this field, first coined the phrase "ubiquitous computing" in describing his proposal for an environment where the computers would be embedded in walls, in tabletops, and in everyday objects.[197] Weiser asserts that "ubiquitous computing enhances computer use by making many computers available throughout the physical environment,

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[195] York,J and Pendharkar, Parag C. "Human-Computer Interaction Issues for Mobile Computing in a Variable Work Context." *International Journal of Human-Computer Studies*. Vol. 50 No. 5-6 (May 2004): 771-797.

[196] Ibid.

[197] Weiser, Mark. "Some Computer Science Issues in Ubiquitous Computing." *Communications of the ACM*. Vol. 36 No. 7 (July 1993): 75-84.

while making them effectively invisible to the user" and where the user interacts with hundreds of computers at a time.[198]

Ubiquitous computing aims to integrate technology in an undetectable way into the daily lives of people and provide for their conscious or unconscious communication with these embedded computers. Although there are diverse ubiquitous computing applications based on HCI models, the common goal in all applications is to provide the integration of human factors, computer science, engineering, and social sciences through using different interfaces, operating systems, and networks.[199]

In ubiquitous computing hundreds of computing devices are integrated into the environment or an object in order to add additional capabilities and functionalities to it. Especially using wireless, mobile, and networked devices, ubiquitous computing enables the connection and collaboration between the users and the environment while processing information at the same time. Definition of on-off conditions of air conditioners or lights in relation to the presence of a person in the room, or open-closed conditions of a window blind depending on natural light levels can be considered as examples of ubiquitous computing.[200] In a similar way, the presentation of contextual information about a particular location or object to a person upon her/his entrance to an area can be considered as an application of ubiquitous computing.[201] It can be noted that the unknown/not recognized presence of computing devices and apparatuses contribute to the continuity of the interaction. The continuous

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[198] Ibid.

[199] York and Pendharkar, "Human-Computer Interaction Issues for Mobile Computing in a Variable Work Context."

[200] Elrod, Scott, Hall, Gene, Costanza, Rick, Dixon, Michael, Des Rivières, Jim. "Responsive Office Environments." *Communications of the ACM*. Vol. 36 No. 7 (July 1993): 84-85.

[201] Lamming, Mik, Brown, Peter, Carter, Kathleen, Eldridge, Margery, Flynn, Mike and Louie, Gifford. "The Design of a Human Memory Prosthesis." *The Computer Journal.* Vol. 37 No. 3 (1994): 153-163.

interaction defined between the human body and the bodies of embedded computing devices and apparatuses may alter the relations between the body and environment. In the third chapter, ubiquitous computing and the relation of the body with the environment will be discussed in relation to the issue of embodiment.

Integration of information processing tasks into objects and environments has some problems related with privacy issues and personalization of information. Tracing and processing the information gathered from the user, the ubiquitous computing environments contain private information about the users. Hence, these environments pose serious privacy risks and can give away information about the actions, preferences, and locations of users which are invisible to others. Another problem related with ubiquitous computing environments is that it is difficult to sustain the personalization of both the information and the system according to different users while at the same time maintaining the economy and sustainability of the system. In each new entry to the environment, the system needs to update its relations and responses according to the personalized information gathered from the user. Besides, the system may also need to update the already gathered and processed data which may create a confusion or extra work-load to the system.

2.4.3 Augmented Reality and Virtual Reality

As information became available in different formats and through different media, ways of accessing information and interacting with it has also altered. Through mobile communication devices, laptops, and PDAs, digital information becomes an integral part of daily life and it becomes possible to store and handle basic and sometimes advanced information processing tasks. For instance, mobile phones and their location services allow the users to interact with the information at a particular location. Although the information is processed at several points through several devices, the user does not have access to this technical loop at the backdrop. It is not a direct response that the responsive system provides, but rather a processed outcome, which takes into consideration the relations defined beforehand. It is the end product of the interaction that the user engages with, which is the outcome of these technical processes.

In augmented reality environments, the efficiency of accessing and interacting with information is enabled through these technical loops. However, augmentation and augmented reality can also be considered as offering an alternative process of interacting with information and fusing computer-generated information with sensations of the natural world.[202]

Closely related with computer science, engineering and human computer interface design, augmented reality is defined as the combination of virtual or digital information and objects in real world/time, where computer generated properties are superimposed on the real world, allowing the user to experience them as if they were real time properties.[203] The composite view that is generated inherits the potential of augmenting the real situation with additional information through the coupling of the human and the augmented reality system. However, if computer-generated images or processes are intended not to enhance physical reality but only replicate the physical environment without providing new synergies between the human and the environment, this situation is identified as simulation. Although these two approaches have long co-existed, the main difference between simulation and augmentation is that augmentation aims to define connectivity between the human body and reality,

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[202] Falk, Jennica, Redström, Johan, and Björk, Staffan. "Amplifying Reality." in *1st International Symposium on Handheld and Ubiquitous Computing.* Proceedings, 274-281. Karlsruhe, Germany, 1999.

[203] Ibid.

and considers this connectivity as an integral part of the process rather than just simulating reality, thus separating the human from the process.[204]

The contemporary discourse and practice of augmentation aims to incorporate computing systems and devices into the physical environment of the human, where the computing systems are conceived as mobile or located on the human body. Enabling dynamic updates and active participation, these systems add computational and communicational capabilities to the physical actors of interaction.[205]

Although augmentation can be attained through different techniques and devices, or through a combination of different computing devices coupled with input and/or output hardware, wearable computers are the most common used ones. Through the integration of head-mounted displays, digital technology, auditory displays, and body tracking technologies, wearable computers enable mutual stimulation through the body. In an augmentation process making use of wearable computers, a new hybrid actor is defined resulting from the coupling of machines and humans, where the composite experience of the information from the real world and the computer allows this hybrid actor to affect and be affected by this composite reality.

The augmentation process can be asserted to enable the connectivity and responsiveness of the interaction process through the coupling of the human and the machine where one affects the other. Although, it is mainly the computer-generated reality that has a deep impact on the physical reality, impacts can also be attained vice versa when the responses from the physical world and the human are considered as a stimulating aspect that transforms the

[204] Floridi, *Philosophy and Computing: An Introduction*.

[205] Gellersen, Hans Werner. "Augmenting Everyday Artefacts with Shared Awareness." in *Information Society Technologies IST'2000.* Proceedings. Brussels, Belgium, 2000.

computer-generated reality. Through this way, the coupling can be satisfied and an interaction process between parties can be defined.

Augmented Reality is considered as a growing area in virtual reality research, therefore the motivation for augmented reality can be traced in the concept of virtual reality. A common goal of researches in computer science in the 80s and early 90s, virtual reality implies "a computer generated, interactive, three-dimensional environment in which a person is immersed." [206] In virtual reality, which employs computer-generated information to produce a digital world similar to the physical world, all actions are predefined.[207] According to Aukstakalnis and Blatner, the user experiencing virtual reality is totally immersed and requires real-time response from the system to be able to interact with it in an effective manner.[208]

In order to attain the desired interactivity and adequate level of realism, the user is not totally detached from the environment. One way of attaining the adequate level of realism is the use of the head mounted displays worn by the user, which block his/her connection with the real world and introduce her/him to the virtual reality through presenting computer-generated graphics.[209] In this experience the visual and aural senses of the user and also the information about the position and the movement of the body captured through sensory systems are controlled by the computer. In augmented reality, the total disconnection of the user from the physical reality is avoided and it is aimed to

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[206] Aukstakalnis, Steve and Blatner, David. *Silicon Mirage; The Art and Science of Virtual Reality* (Berkeley, CA: Peachpit Press. 1992).

[207] Ibid.

[208] Ibid.

[209] Vallino, James R. "Interactive Augmented Reality." PhD diss., University of Rochester, 1998.

maintain the sense of presence in physical reality.[210] Through this way, the composite experience of real, digital and virtual is attained. Another distinction between virtual reality and augmented reality is that, although in virtual reality the user is introduced to a new environment and controlled by the system, in augmented reality the user is enabled to experience him/herself in the physical environment and transform the environment or manipulate the objects once s/he participates in the process.

Researchers working with augmented reality systems have proposed their use in many domains such as entertainment, military training, medical research and robotics.[211] This technology has the potential of improving the interaction with the body such as armbands that monitor sleep used for gathering information about the body[212] or shirts that sense the heartbeat and aimed to detect and control heart attacks.[213]

In this chapter, an overview of the concept of responsiveness has been provided and the developments in the field or adjacent fields of responsive environments have been scrutinized. These advances are considered as significantly influencing architecture and the experience of the environment. Although the examples discussed in this chapter are mainly installations, or small scale architectural proposals, they are considered as initial applications of the concept of responsiveness in architecture.

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[210] Dwinght Holland, Dawn J. Roberson and Woodrow Barfield. "Computing Under the Skin." *Fundamentals of Wearable Computers and Augumented Reality*. Mahwah, NJ : Lawrence Erlbaum Associates, 2001.

[211] Barfield, Woodrow and Caudell, Thomas. "Preface." *Fundamentals of Wearable Computers and Augumented Reality*. Mahwah, NJ: Lawrence Erlbaum Associates, 2001.

[212] Wysocki, Bernard. "In Sickness and Health, Biometrics Field Grows." Wall Street Journal. 2011. http://startupjournal.com/columnists/challengers/bodymedia/2001081Owysocki.html. [Accessed: May, 2011].

[213] Nowland, J. "Smart Shirts to Revolutionize Healthcare."2003. http://www.chinapost.com.tw/business/detail.asp?ID=42338&GRP=E. [Accessed: May, 2011].

It is also revealed in this chapter that these practices alter the definition and also the experience of the responsive environment and transform the relationships between the environment and the participants. These new relationships engender a new understanding and definition of the environment.

In order to provide for highlights in the concept of responsiveness and the altered definition of environments, real-time data processing methods and advanced communication technologies that enable to share and exchange information simultaneously have been covered in this chapter. The considered methods and technologies also reveal the potentials that facilitate the interactions between participants, their environment and wider networks. Through revealing the technical and theoretical discussions behind the concept of responsiveness, it is aimed to provide for an understanding of the technical loop running at the backdrop of a responsive mechanism, which is usually invisible to the human, and the motivating advances that support this loop. Understanding of this technical loop enables to identify the search for the use of machines instead of mechanisms in responsive environments, which enable the contribution of the bodies to the interaction process and also the embodiment of relations defined/redefined during the human-machine interaction.

The following chapter considers the debates in the philosophy of mind and the mind-body relationship, specifically focusing on the changes experienced in the definitions and conditions of body and embodiment in responsive environments. The discussions provided in this chapter in relation to the concept of responsiveness and responsive environments help to understand how the simultaneous transformation of the definition of the body and the experience of embodiment is enabled in relation to changes in the relations in responsive environments.

CHAPTER 3

EMBODIMENT AND COGNITION: ALTERED EXPERIENCES THROUGH EXTENDED BODIES AND MINDS

Machines and machinic approaches acknowledged in the definition of responsiveness that make use of the technological advances and computational strategies propose a re-conceptualization of the human machine interaction. This re-conceptualization is technically enabled through the mechanical environment running at the backdrop of responsive environments, which has been mapped in the previous chapter in reference to the developments that guide advances in these strategies, tools and materials. This thesis argues that, machinic approaches, where the machine is conceptualized as a transforming entity opening up new relations, connections, and mutations while interacting with human or non-human agents, can alter and re-problematize the body and the question of its embodiment. The following chapter will discuss how machinic approaches define the body as a dynamic entity and provide for the problematization of embodiment as unstable and inseparable from the environment.

In order to understand and map the problematization of body and embodiment in the human-machine interaction provided in machinic approaches, this thesis refers to different attempts at defining the relation between mind and body within the philosophy of mind. Highlighting Deleuze's definition of the body and embodiment, this part of the research provides for an understanding of the transformations defined in the conception of body and embodiment by responsive environments. In this respect, this chapter refers to cognitive science and different conceptions of mind-body relationship that affect the definition and study of cognition. After discussing dualism, monism, behaviorism, and cognitivism, it is referred to the approaches that consider the embodiment of cognition. As a significant approach to this problematic, Deleuze's definition of body and embodiment is scrutinized, of which reflections can be traced in machinic approaches and responsive environments making use of such approaches. These analyses also consider the ways of altering the perception of embodiment through responsive environments, while reflecting on Deleuze's philosophy of body and embodiment.

3.1 Cognitive Science

Cognitive science has different definitions according to the period and disciplines it is studied in, though it has historically been embraced as a particular view of the mind regarding human mental states and processes.[214] Even though the critical shift in the studies on mind and intelligence as a science is considered to happen in the 1950s, the roots of cognitive science can be traced back to Classical Greek philosophy.[215]

The key contributions to the development of cognitive science are mainly the studies in cybernetics and a symposium, "Symposium on Information Theory", held in 1956 at the Massachusetts Institute of Technology with the contributions of scientists from different fields, such as psychologist George Miller, computer scientists Allen Newell and Herbert Simon, and linguist Noam Chomsky.[216] The collaborative and interdisciplinary nature of cognitive science was then put forward through this early symposium and researchers from several fields developed theories of mind based on computational

[214] Allen, Colin. *Species of Mind: The Philosophy and Biology of Cognitive Ethology* (Cambridge, Mass.; London: MIT, 1999), 54.

[215] Tarnas, Richard. *The Passion of the Western Mind: Understanding the Ideas That Have Shaped Our World View.* New York: Ballantine.1991.

[216] Dawson, Michael. *Understanding Cognitive Science* (Malden, Mass.: Blackwell, 1998), 3.

procedures.[217] Until the introduction of the issue of embodiment, studies in cognitive science embraced a view of the mind which conceptualized human mental states and processes as the product of internal mental processes. This particular view, where the human mind was studied and understood independently of any reference to the environment, guided studies in cognitive science for a long time. With the involvement of the notion of embodiment in the debates on cognition, the body is considered as an experiential structure and as the context of cognitive mechanisms.[218] This change is argued to lead to a new interdisciplinary structure, where cognitive science is considered as a matrix being composed of different interdisciplinary studies such as: philosophy, psychology, artificial intelligence, neuroscience, linguistics, and anthropology.[219]

In this transformative process, several scientists defined the nature and scope of cognitive science. For instance, Howard Gardner defines cognitive science as a "contemporary, empirically-based effort to answer the long-standing epistemological questions—particularly those concerned with the nature of knowledge, its components, its sources, its development, and its deployment."[220] Lynn Nadel defines cognitive science as the scientific study of minds and brains of real or artificial humans or animals.[221] On the other hand, Francisco Varela considers cognitive science as an affiliation of disciplines

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[217] Thagard, Paul. *Mind: Introduction to Cognitive Science* (Cambridge, Mass.: MIT Press, 2005).

[218] Varela, Franscisco J., Thompson, Evan T. and Rosch, Eleanor. *The Embodied Mind: Cognitive Science and Human Experience* (Cambridge, Mass.: MIT Press, 1992).

[219] Ibid.

[220] Gardner, Howard. *The Mind's New Science: A History of the Cognitive Revolution* (New York: Basic Books, 1987).

[221] Nadel, Lynn and Piattelli-Palmarini, Massimo. "What is Cognitive Science?" *Encyclopedia of Cognitive Sceince* (London, Nature Pub. Group, 2003).

contributing to each other and underlines that the term cognitive science is used to indicate that “the study of mind is in itself a worthy scientific pursuit.”[222]

Gardner in his work identifies the features he associates with cognitive science in order to provide a coherent understanding of the references of cognitive science.[223] Although he notes that all cognitive scientists embrace every feature, he puts forward five features as indications of the cognitive-scientific attempt. Initially, Gardner states that in cognitive science studies, there is a general tendency to associate human cognitive activities with mental representations and to provide for a position detached from the biological, neurological, and sociological levels of discussion.[224] Second, Gardner emphasizes that any understanding of the human mind is associated with the electronic computer since the computer serves as a viable model of how the human mind functions. [225] The third feature according to Gardner, is the deliberate attempt to de-emphasize certain factors, which may complicate the cognitive-scientific enterprise, such as the influence of emotions, the contribution of historical and cultural factors, and the role of the background context.[226] As the fourth feature, he puts emphasis on the belief that cognitive science can take the advantage of interdisciplinary studies and gain knowledge from several fields. [227]In the fifth feature, Gardner claims that the philosophical tradition dating back to the time of Greeks also contributes to cognitive science, together with the agenda of issues and the set of concerns which have long been exercised by the epistemologists in the Western philosophical

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[222] Varela, Thompson, and Rosch, *The Embodied Mind: Cognitive Science and Human Experience*, 4.

[223] Gardner, *The Mind's New Science: A History of the Cognitive Revolution,* 6.

[224] Ibid.

[225] Ibid.

[226] Ibid.

[227] Ibid.

tradition such as the subject-object dichotomy, which is discussed in detail in section 3.3.1.[228]

The key theoretical inputs to cognitive science are the developments in mathematics, computation, neural models, parallel distribution strategies, neuropsychological studies etc. These recent contributions can be asserted to be under the dominance of studies on intelligence and the active contribution of computational tools and strategies. Gallagher and Zahavi assert that there has been a significant change in cognitive sciences in the late 1980s and early 1990s, as a consequence of the interest in phenomenal consciousness, embodied cognition and processes in neuroscience that they cite as the three significant developments mainly contributing to this change.[229]

According to Gallagher and Zahavi, there has been a renewed interest in phenomenology and phenomenal consciousness in the late 1980s and early 1990s.[230] They state that starting in late 1980s, the issue of consciousness has been discussed within the context of the cognitive sciences.[231] They observe that as a consequence of the methodological questions arising about the experiential dimension of consciousness and cognition (especially with the studies of David Chalmers, Thomas Nagel, Daniel Dennett, and Owen Flanagan) a new debate on phenomenology has been started. [232] In this respect, philosophical approaches have been included in the debate where the issue of consciousness used to be handled only as a scientific matter.[233]

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[228] Ibid, 7.

[229] Gallagher, Shaun and Zahavi, Dan. *The Phenomenological Mind: An Introduction to Philosophy of Mind and Cognitive Science* (London, New York: Routledge, 2008).

[230] Ibid.

[231] Ibid.

[232] Ibid, 4-5.

[233] Ibid.

Another development that contributed to the mentioned change is identified as the introduction of embodied cognition, especially after the 1990s, by a group of scientists and philosophers, who rejected the Cartesian approach to the mind-body relationship.[234] These scientists, some of which are Francisco Varela, Evan Thompson, Eleanor Rosch, George Lakoff, Mark Johnson, and Andy Clark, objected to disembodied cognition and triggered the approaches that fused phenomenology with the studies in cognitive sciences.[235]

The progress in neuroscience is considered as another development that has a significant role in the definition of the change in the 1980s and 1990s, by way of associating phenomenological approaches to cognition. Gallager and Zahavi underline the association between phenomenological philosophy and methodology in cognitive science and state that:

> "Both in order to design experiments properly and in order to interpret their results, experimenters often want to know what the subject's experience is like. Again, the issue of methodology calls for some consideration of dependable ways of describing conscious experience, and phenomenology offers just such a method."[236]

These attempts of defining the cognition and cognitive processes inherit the discussion of the mind-body relation. Different attempts to define the mind-body relationship and cognitive processes throughout the history enables to understand the experienced structure.

The following section concentrates on the definition of the mind-body relationship through references to significant figures in the philosophy of mind. The following section is also an introduction to the assessment of the re-

[234] Ibid.

[235] Ibid.

[236] Ibid.

problematization of embodiment in light of different conceptions of the mind-body relationship.

3.2 The Mind-Body Problem

Traditionally discussed under the heading of 'The Mind–Body Problem," the relation of mind to the body is a philosophical problem arising in different fields, that questions how a person's mental states (mind) are related to his/her physical states (body). The philosophy of mind mainly concerns the problems, which are associated with the functioning of the mind and body/brain. Discussions related with these problems takes into consideration whether the mind is separate from the body/brain, a by-product of it or in coordination with it. The debates on these problems correspond to different standpoints in different periods. The primary aim of this section is to explain these different approaches to this problem and expose the transformation of the mind-body relation in reference to developments in technology and different conceptualizations of the body. Although, there is no settled agreement on a specific definition to the relation between mind and body, the two main approaches that can be distinguished are dualism and monism.

3.2.1 Dualism

In dualism, mind and body are considered as two distinct substances separable from each other and the body is defined as the embodiment for the human mind.[237]

According to this view, a person's mind is not identical with his body and the embodiment of mind is denied.[238] Emphasizing the distinction between mind

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[237] Uttal, William R. *Dualism: The Original Sin of Cognitivism* (N.J.: L. Erlbaum Associates, 2004).

[238] Searle, John R. *Mind: A Brief Introduction* (Oxford, New York: Oxford University Press, 2004), 13.

and body, dualists either deny that the mind is the same as the brain, or assert that that the mind is wholly a product of the brain.[239] This concept of dualism can be traced back to Greek thought, where the soul and the body were regarded as entirely different essences having no interaction with one another.[240] The Greek dualism identified these entities as being unfamiliar to each other and considered the human body as being separate from the external world. [241] Although there are different concepts of dualism in the philosophy of mind, the Greek thought is considered as providing the first discussions on the issue.[242]

This dualistic position can be traced particularly in Plato's dialogue *Phaedo*, where the twofold condition of the human is described as being separated into soul/mind and body.[243] His theory is based mainly on the dual nature of human beings where the soul/mind is considered as the essence of man.[244] According to Plato the body is from the material world, whereas the soul is from the world of ideas and immortal. He argues that their combination is a temporary condition and can be separated. As defined by Plato, the soul experiences the ideas whereas the body cannot access the "abstract reality" of the world and is empty.[245]

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[239] Uttal, *Dualism: The Original Sin of Cognitivism*.

[240] Custance, Arthur C. and Travis, Lee Edward. *The Mysterious Matter of Mind* (Texas: Zondervan Publishing Co., 1979).

[241] Uttal, *Dualism: The Original Sin of Cognitivism*.

[242] Custance and Travis, *The Mysterious Matter of Mind*.

[243] Plato. *Plato's Phaedo* (Cambridge: Cambridge University Press, 1980).

[244] Plato. *Timaeus; Critias; Cleitophon; Menexenus; Epistles* (Cambridge, Mass.: Harvard University Press, 1999).

[245] Lanigan, Richard L. *Phenomenology of Communication: Merleau-Ponty's Thematics in Communicology and Semiology* (Pittsburgh: Duquesne University Press, 1988).

Although the distinction between mind and body can be traced in Greek thought and in Plato's arguments, it is generally associated with the works of René Descartes. A French mathematician, philosopher, and physiologist, Descartes is considered to provide the first systematic account of the mind-body relationship (figure 18) and to formulate the mind-body problem through distinguishing the mind (as a nonphysical substance identified with consciousness) from the brain (considered as the seat of intelligence).[246]

Descartes identifies the mind-body relationship in his work *Meditation VI,* and argues that the mind, of which essence is thought, can exist apart from its extended body. He states, "I have a clear and distinct idea of myself as a thinking, non-extended thing, and a clear and distinct idea of body as an extended and non-thinking thing."[247] He considers the mind as a "thinking thing" that doubts, believes, hopes, and thinks and claims that it is the essence of the human being.[248] Descartes marks out the twofold condition of the human being defined as being composed of mind and body, which are separable from each other. In Descartes view, the mind is immortal and the body is a perception.[249] He explicitly distinguishes mind from body and identifies the body as the embodiment of the human mind.[250]In Descartes' dualist view, the mind itself does not necessitate embodiment in order to maintain its existence

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[246] Descartes, René. "Meditations on First Philosophy." *The Philosophical Writings of René Descartes* (Cambridge: Cambridge University Press, 1984).

For Descartes, the brain and the mind are not the same thing since the brain is a physical, changeable thing and hence he didn't consider it as the actual mind. However, according to Descartes, man's mind is whole and indivisible, whereas his body can be changed.

[247] Descartes, *The Philosophical Writings of René Descartes*, 234.

[248] Gibbs, Raymond W. *Embodiment and Cognitive Science* (Cambridge: Cambridge University Press, 2005), 4.

[249] Baker, Gordon P. and Morris, Katherine. *Decartes' Dualism* (London, New York: Routledge, 2002), 4-6.

[250] Alanen, Lilli. *Descartes's Concept of Mind* (Cambridge, Mass.: Harvard University Press, 2003).

and perform the specialized actions.[251] According to Descartes, the mind functions separately from the body, where neither of them can affect the other. However, they can interact and complement each other through this interaction. This form of dualism constitutes the basic structure of the Cartesian mind-body relationship, in which the body is identified as separate from the non-material, rational mind.[252] These definitions are considered as the essentials of what is called the Cartesian mind-body split, also known as Cartesian dualism.

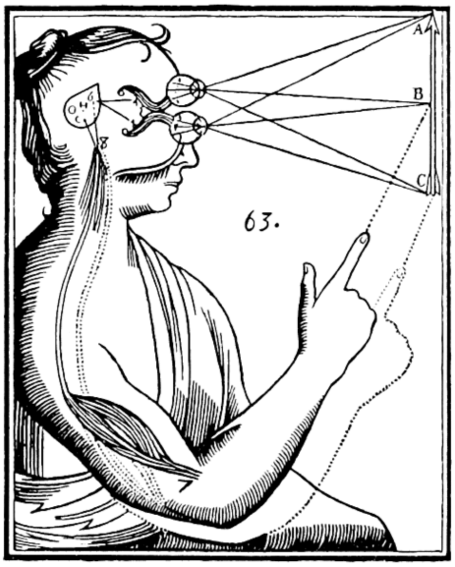

Figure 18: Descartes' illustration of mind-body dualism.

Source: Descartes, René. "Meditations on First Philosophy." *The Philosophical Writings of René Descartes*. Trans. J. Cottingham, R. Stoothoff and D. Murdoch, Cambridge: Cambridge University Press, 1984.

In Cartesian dualism, mind and body may differ in function but they do complement each other while interacting at the brain.[253] In this interaction, the brain serves as a link between these two distinct substances where the body

[251] Descartes, René. *Discourse on Method and the Meditations* (Baltimore, Penguin. 1968).

[252] Gibbs, *Embodiment and Cognitive Science*, 4.

[253] Descartes, in his letter to Elisabeth of Bohemia, Princess Palatine, he suggested that animal spirits interacted with the body through the pineal gland, a small gland in the centre of the brain, between the two hemispheres.

affects the mind or vice versa. Descartes believes that it is the pineal gland where this interaction between the mind and the body occurs. The relevant quotation as to Descartes' reason for this belief is as follows;

> "Although the soul is joined to the whole body, there is yet in the body a certain part in which it seems to exercise its functions more specifically than in all the others. . . I seem to find evidence that the part of the body in which the soul exercises its functions immediately is. . . solely the innermost part of the brain, namely, a certain very small gland… When we wish to move the body in any manner, this volition causes the gland to impel the spirits towards the muscles which bring about this effect."[254]

Although mental events enable physical events, the body can also influence the soul and cause mental events. Cartesian dualism is often associated with this notion of interaction even though it inherits the question of how can the immaterial mind cause any change in the material body.[255]

3.2.2 Types of Mind-Body Dualism

It is possible to trace different approaches to mind-body dualism, which are in conjunction with the above mentioned discussions at some points. The three main approaches are substance dualism, property dualism and predicate dualism.[256]

Substance dualism, which is specifically called Cartesian dualism, is discussed in the previous section. Substance dualism is structured on the distinction between mind and body and considers the statements of Descartes

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[254] Descartes, Rene. *Descartes' Philosophical Writings* (London: Macmillan, 1952).

[255] Lycan, William G. "The Mind-Body Problem." *The Blackwell Guide to Philosophy of Mind* (Wiley-Blackwell, 2003), 47-64.

[256] Cunningham, Suzanne. What *is a Mind?: An Integrative Introduction to the Philosophy of Mind* (Indianapolis: Hackett Publishing Co., 2000).

as the essential arguments. In this approach, it is considered that there are two fundamental kinds of substance; mental and material. [257] According to the philosophy of Descartes, although the material (body) substance cannot think, the mental (mind) substance is capable of thinking and does not have extension in space. [258]

On the other hand, **property dualism** argues that human beings have two distinct sets of properties: physical properties and mental properties.[259] This approach takes into consideration the distinctions between the properties of mind (mental) and matter (physical). It suggests that the brain has both physical (for instance shape, weight, color) and mental properties (for instance consciousness, beliefs, desires). In this dual existence the mental properties are asserted to emerge as a consequence of the processes in the brain.[260] Hence, the property dualism approach objects the independent existence of mental substance that is considered as the main argument of substance dualism. From another point of view, property dualists assert that, mental properties emerge when the processes in the brain reach a certain level of complexity. Therefore, the complexity of the physical properties is considered to give rise to the emergence of mental properties such as consciousness, beliefs, and desires.[261]

Another approach to mind-body dualism is **predicate dualism**, which claims that the predicates used to describe mental events cannot be reduced to physical predicates of natural languages.[262] In this approach, the dual existence of

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[257] Ibid.

[258] Ibid.

[259] Ibid.

[260] Ludwig, Kirk. "The Mind-Body Problem: An Overview." *The Blackwell Guide to Philosophy of Mind.* (Wiley-Blackwell, 2003), 1-46.

[261] Ibid.

[262] Fodor, Jerry A. "Special Sciences, or The Disunity of Science As A Working Hyphothesis." Synthèse. Vol 28 (1974): 97-115, quoted in Robinson, Howard. "Dualism," *The Blackwell Guide to Philosophy of Mind.* (Wiley-Blackwell, 2003), 85-101.

mental and physical predicates is considered as the essential condition for a coherent understanding. This approach differs from property dualism in the sense that it denies the reduction of psychological or mental predicates to physical predicates and considers their dual existence. A common used example for predicate dualism is the difference between the concepts of water and hurricane. It is asserted that even if one replaces the word ‘water’ by ‘H_2O’ one could still convey the same information and feeling.[263] However, the terms in many of the special sciences are asserted not to be reducible in this way.[264] For instance, while describing a hurricane, both the state and the constitutive structure of the hurricane should be indicated in order to provide a coherent understanding.[265] Therefore, the definition of hurricane necessitates functional terms. Unlike the case of water, it may not be possible to convey the same meaning and information about the hurricane simply through physical descriptions.

After Descartes’ approach, many philosophers provided alternative attempts to understand the relation between mind and body and tried to avoid the difficulties stemming from the claims of Cartesian dualism. Spinoza and Leibniz are the key figures in the early attempts to overcome the dilemmas discussed in Descartes’ formulation of mind and body. They provide alternative formulations for the mind-body relationship and propose the idea of multiple minds. Later attempts, which arise in the 19th century, associate the discussions of mind-body relationship with studies in biology (especially on the cerebral functions and nervous disorders) and psychology. In these attempts

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[263] Robinson, Howard. “Dualism.” *The Blackwell Guide to Philosophy of Mind*. (Wiley-Blackwell, 2003), 85-101.

[264] Ibid.

[265] Ibid.

the brain is recognized as the organ of mind and hence these approaches are oriented towards avoiding the dualism of the Cartesian approach.[266]

3.2.3 Monism

Monism as a philosophical approach followed by philosophers, psychologists, and physicians in different disciplines with different references. Contrasting with dualism, in monism, body and mind are considered as one substance.[267] Despite the dualists' claims on the mind-body relationship, in monism, it is argued that the person is made up either of body or mind.[268] There are two basic types of monism; materialism and idealism. The basic difference between these two approaches is their claim on the constitutive substance of the human being. According to the materialist view, "all that exists is matter, configured into material objects," whereas in the idealist view, it is the mind or spirit that exists and constitutes the human being.[269]

There are various attempts to define the mind-body relationship while providing opposing views to the dualist approach. Three of these approaches are introduced in the following sections where it is aimed to understand Spinoza's, Leibniz's and Merleau-Ponty's interpretations of the mind-body relationship.

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[266] Gibbs, *Embodiment and Cognitive Science*.

[267] Uttal, *Dualism: The Original Sin of Cognitivism*.

There exist different sub-theories of monism where, monist materialists take the view that they are both matter, and monist idealists take the view that they are both in the mind. On the other hand, neutral monists take the view that both are reducible to a third, neutral substance.

[268] Morris, Joseph. *A New Natural Theology; Based Upon the Doctrine of Evolution* (Memphis: General Books LLC, 2010), 155.

[269] Ibid.

3.2.3.1 Spinoza

The causal relationship between the mind and the body can be considered as one of the main philosophical issues of the seventeenth century. In this period, most of the discussions on the mind-body relationship were concentrated on their dual existence. One of the alternative approaches to this dual existence is given by Spinoza.

Spinoza considers minds and bodies as dependent instances. In this sense, Spinoza's approach opposes the claims of the Cartesian Dualist approach, where the mind and the body are considered as independent substances. Spinoza reconsiders the definition of the mind and tries to re-conceptualize it within the framework of scientific theory. He identifies the association between nature and mind and explains the body in reference to nature.[270] He defines nature as being made up of small particles, which he called "simplest bodies," and identifies bodies as being composed of these simplest bodies. The significant quotation for Spinoza's claim for the composition of bodies is as follows;

> "When a number of bodies of the same or different magnitude form close contact with one another through the pressure of other bodies upon them, or if they are moving at the same time or at different rates of speed these bodies are said to be united with one another and all together to form one body or individual thing which is distinguished from other things through this union of bodies."[271]

The individual bodies made up of simple bodies are in fact defined as part of a larger composite body. Therefore, the whole nature is considered as an individual body that is composed of simpler bodies at each level. This

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[270] Cahn, Steven M. *Classics of Western Philosophy* (Indianapolis: Hackett Pub. Co., 2006).

[271] Ariew, Roger. *Readings in Modern Philosophy: Descartes, Spinoza, Leibniz, and Associated Texts* (Indianapolis: Hackett Pub. Co., 2000).

association between nature and human body is considered as the fundamental claim of Spinoza’s theory. With these claims, Spinoza’s approach opposes Cartesian dualism and eliminates the mental substance in the dualist approach to propose a conceptualization of the mind through physical acts. Rejecting the relationship and interaction identified between mind and body in Cartesian dualism, Spinoza claims that; “the ideas constituting the mind are the ideas produced by the body.”[272]

3.2.3.2 Leibniz

Another alternative approach to the Cartesian mind-body split is provided by Leibniz. In a similar manner with Spinoza, Leibniz also states that there is only one type of substance in the world and argues that both the mind and the body are composed of the same substance. In this sense, Leibniz’s approach can be associated with Spinoza’s where both are attempts to provide alternatives to the mind-body relation proposed in Cartesian Dualism. However, the approaches of Spinoza and Leibniz also have some distinct parts. Whereas Spinoza leaves the mental substance (mind) out, Leibniz proposes the opposite and focuses especially on the mental substance (mind).

Another important distinction between the approaches of Spinoza and Leibniz is the definition of the simple parts that form the composite substances. Although they both mention about these composite substances, the parts constituting the composite differ in the two approaches. Spinoza points out the relation between simple bodies and composites whereas Leibniz mainly indicates the relation between monads and aggregates.

In *Monadology*, Leibniz suggests that all compound things are composed of monads, that is, simple substances without parts. He defines a monad as a

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[272] Ibid.

simple substance, which cannot be divided into parts. A compound substance may be formed by an aggregation of monads and be divided into simple parts, which are not affected by others.[273] He also identifies monads as sizeless entities, of which minds are the only accessible examples. [274] For Leibniz "not every monad is a mind; but the states of any monad are just its perceptions, in which the states of all the other monads are represented; and minds differ from other monads only in degree."[275] Through its distinct perception, each monad differs from the others and gains a distinct and different character.

In *Monadology*, each monad proposes its own identity, possesses its own internal principle of being, and changes according to its own internal actions. Leibniz claims that: "Changes in the properties of any monad are not externally determined by other monads," but rather internally determined.[276] Leibniz also mentions about the situation where individual monads have impacts on each other and define interactions between each other. He states in *Monadology* that; "The creature is said to act externally in so far as it is perfect, and to be acted upon by another, in so far as it is imperfect. In consequence, action is attributed to the monad in so far as it has distinct perceptions and passion in so far as it has confused perceptions."[277] In reference to this explanation, it can be asserted that each monad has its own perceptions different from the perceptions of other monads. Leibniz describes three levels of monads, which can be differentiated by their modes of perception. A simple or bare monad has unconscious perception and no memory. A simple or ordinary soul is a more highly

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[273] Leibniz, Freiherr von Gottfried Wilhelm. *Discourse on Metaphysics and Other Essays* (Indianapolis: Hackett, 1991).

[274] Leibniz, Gottfried Wilhelm, Freiherr von. *Discourse on Metaphysics, and The Monadology* (Mineola, N.Y.: Dover Publications, 2008).

[275] Ibid.

[276] Leibniz, Gottfried Wilhelm, Freiherr von. *New Essays on Human Understanding* (Cambridge: Cambridge University Press, 1996).

[277] Leibniz, *Discourse on Metaphysics and Other Essays*.

developed monad, which has distinct perceptions, conscious awareness, and memory. A rational soul or spirit is an even more highly developed monad, which has self-consciousness and reason. [278]

Criticizing the Cartesian thought for considering only the minds as monads, Leibniz states that:

> "the passing state which involves and represents a multitude in the unit or in the simple substance is nothing other than what one calls perception, which should be distinguished from apperception, or consciousness, as will be evident in what follows. This is where the Cartesians have failed badly, since they took no account of the perceptions that we do not apperceive. This is also what made them believe that minds alone are monads and that there are no animal souls or other entelechies..."[279]

According to Leibniz's definitions, any interaction between mind and body is purely perceptual and the human does not necessitate his/her body to explain mental states. He denies the causal relationship between the mind and the body and provides and alternative approach to mind-body dualism. In his critique of Cartesian Dualism, Leibniz also considers multiple monads and provides an important discussion ground for multiple and parallel processing issues. The connection between monads and their impacts on the internal and external properties of each other are considered as leading to a continuous change in their perceptions and conditions. In Leibniz's universe, bodies can be considered as being under the influence of some other bodies, remote from each other or intimately nested, that provide the potential of influencing and responding to each other. Laurence Bouquiaux highlights this condition and states that:

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[278] Leibniz, *New Essays on Human Understanding*.

[279] Leibniz, *Discourse on Metaphysics, and The Monadology*.

> "Leibniz's universe is a world where everything is in a perpetual state of flux, a world where everything is constantly transformed. There is no immobility, no rest. The world is full of souls, and the soul is perpetual restlessness. Substances are enveloped and developed, fold and unfold, are extended and drawn together, concentrated."[280]

The continuous interaction and change mentioned in Leibniz can help understand the current developments emphasizing the multiplicity of information processing or producing. For instance, the ideas proposed in Leibniz's approach can be traced in responsive mechanisms, which consider mental or behavioral phenomena emerging from interconnected networks. In these cases, either the human or the machine participant, both monads of different degrees, expresses some sort of responsiveness since the network between them enables the communication and results in the responsiveness of the environment. Hence, Leibniz's *Monadology* can be considered itself as a form of responsiveness, where each monad can influence others through the mutual intervention defined between them. Through the multiplication of monads, different experiences can be provided in responsive environments. This view contrasts the Cartesian approach where the mind is idealized as unique.

3.2.3.3 Merleau-Ponty and the Corporeal Schema

Another important figure in the mind-body discussion is Merleau-Ponty, who provides again an alternative approach opposing the Cartesian view and highlighting the debate on embodiment and perception. Merleau-Ponty rejects the dualities between consciousness and body or between the body and the external world, and states that the body must be non-dualistic.[281] With this

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[280] Bouquiaux, Laurence. *On A Mathematical 'Neo-Aristotelism' in Self-Organization and Emergence in LifeSciences* (Dordrecht: Springer, 2006).

[281] Merleau-Ponty, M. *Phenomenology of Perception* (London: Routledge and Kegan Paul, 1962).

proposition, he denies the mind-body dichotomy proposed in Cartesian dualism and also discards the interaction occurring between these two substances. Therefore, Merleau-Ponty defines the body as being in direct relation to the world and considers consciousness as the projection of the body into the world.[282] Focusing on the relationship between consciousness and embodiment, he states that:

> ". . . consciousness projects itself into a physical world and has a body, as it projects itself into a cultural world and has its habits: because it cannot be consciousness without playing upon significances given either in the absolute past of nature or in its own personal past, and because any form of lived experience tends toward a certain generality whether that of our habits or that of our bodily functions."[283]

Taking into consideration the statements of Merleau-Ponty, it can be claimed that consciousness is directly related with one's body, hence inherits the discussion of embodiment. Along with this debate, he also relates consciousness with perception. According to Merleau-Ponty, perception applies not only to one's body, but also to the external world and inherits an overall sense of the body and subject.[284] This overall sense is called as 'corporeal schema' and defined as "an incorporated bodily know-how and practical sense; a perspectival grasp upon the world from the 'point of view' of the body."[285] The corporeal schema is asserted to extend the social interaction, which can be enlarged or diminished, through the incorporation of alien elements."[286] Merleau-Ponty provides the example of a blind man for the

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[282] Ibid.

[283] Ibid.

[284] Ibid.

[285] Crossley, Nick. *The Social Body: Habit, Identity and Desire* (London: Sage, 2001).

[286] Ibid.

extension of the corporeal schema through the use of external elements. [287] In this specific example, the blind man uses a stick as an external element. The stick acts as an area of sensitivity for the blind man and extends his perception. In a similar manner, the prosthesis or wearable technologies used in augmented reality, simulation, virtual environment studies and responsive environments for different types of extensions such as aural, visual, perceptual etc., can also be considered as contemporary reflections of this approach.

3.2.4 Behaviorism

Behaviorism dominated the study of psychology until the 1970s and considered the mind as the behavior of the body.[288] According to Howard Gardner, one of the main propositions that the behaviorists put forth is that researches on behavior should be constructed with public methods of observation and be applied and quantified by any other scientist.[289] In this sense, the subjective assessments and introspections have been excluded from the research and evaluation processes.[290]

According to Gardner, the behaviorist studies aim to clarify psychological activity by focusing only on behavior and avoiding topics such as mind, thinking, or imagination, and concepts such as plans, desires, or intentions.[291] Without considering the mental constructs like symbols, ideas, schemas, or other possible forms of mental representations, behaviorism tries to eliminate

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[287] Merleau-Ponty, *Phenomenology of Perception*.

[288] Searle, *Mind: A Brief Introduction*.

[289] Gardner, *The Mind's New Science: A History of the Cognitive Revolution.*

[290] Ibid.

[291] Ibid.

the mind entirely from subjective evaluations.[292] Varela considers this elimination as the main problem of behaviorism and states that;

> "Behaviorism was particularly compatible with the early twentieth-century positivist zeitgeist of disembodied objectivism in science, for it eliminated mind from its psychology. According to behaviorism, although one could objectively observe inputs to the organism (stimuli) and outputs (behavior) and could investigate the lawful relationships between inputs and outputs over time, the organism itself (both its mind and its biological body) was a black box that was methodologically unapproachable by behavioral science (hence no rules, no symbols, no computations)."[293]

Varela criticizes the behaviorist approach for not considering experience. Paul Churchland, who criticizes the causal relations that the behaviorist approaches, provides another critical approach to behaviorism. According to Churchland, the "essential or defining feature of any type of mental state is the set of causal relations it bears to environmental effects of body, other types of mental states and bodily behavior."[294]

The first signs of post-behaviorist research trying to overcome these problems have emerged in the late 1950s with studies on cognitive phenomena: of perception, memory, language, problem solving, concepts, and decision-making.

Cognitivism is considered as a dominant subject in psychology in the late 20th century, replacing and extending the statements of behaviorism, which has

[292] Ibid.

[293] Varela, Thompson and Rosch, *The Embodied Mind: Cognitive Science and Human Experience*.

[294] Churchland, Paul M., *Matter and Consciousness: A Contemporary Introduction to the Philosophy of Mind* (Cambridge, Mass.: MIT Press, 1988).

been one of the popular paradigms for understanding the mental functions of human beings.

3.2.5 Cognition and Cognitivism

The term cognition is studied in different disciplines with different perspectives. Considering the human faculties for gaining and processing information, thinking, problem-solving etc., cognition or cognitive processes are discussed notably in the fields of linguistics, neurology, psychology, philosophy, and computer science.

The common aspect in the studies on cognition is that, they mainly regard cognition as an internal mental process and exclude the environment from the analyses.[295] These studies try to understand the human mental processes such as recognition, comprehension, interpretation, judgment, and memory in relation to mind and intelligence and have been influenced by philosophical standpoints which consider the mind as separate from both the body and the world.[296] Considering the cognitive processes as internal mental activities, from which knowledge is derived and by which responses are generated, cognitivism regard the mind as holding the representations of the world. The knowledge, in these cognitive processes is generated upon the structure of these representations, where they are regarded as guides for the action and experience of the human. [297]

Attempts at defining cognitive processes as informational, computational, and representational processes where it is tried to understand the mind through

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[295] Haugeland, John. "The Nature and Plausibility of Cognitivism." *Behavioral and Brain Sciences.* Vol.1 No. 2 (1978): 215-260.

[296] Van Gelder, Timothy. "Dynamics and Cognition." *Mind Design II: Philosophy, Psychology, and Artificial Intelligence* (Cambridge, Mass.: MIT Press, 1997).

[297] Ibid.

disembodied conceptions are criticized in the sense that cognition cannot be explained only through these references. As a reaction to cognitivist theory, different means of embracing the embodied and situated approaches are introduced, which conceive of cognition in reference to the human body and his/her interaction with the physical and/or social environment.[298] Running in accordance with the transformations in the conception of the mind-body relationship, the shift from the cognitivist focus on the mind to the necessity of embodiment interprets the human body and the interaction of the human with the physical and social environment as intimate references of cognition and represents the internal cognitive processes with direct references to the external world. [299]

3.2.5.1 Embodied Cognition

Emphasizing the formative role of the environment in the construction and development of cognitive processes, embodied cognition argues that cognitive processes develop when there is a coupling and interaction between the agents, which can be humans, robots or other creatures and their environment. Embodied cognition refers to the condition that arises from the interaction between the mind, body and the environment. [300] In these definitions, embodiment is considered as a condition where the agent interacts with its environment through its sensorimotor capacities and influences the formation and development of cognitive capacities.[301]

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[298] Anderson, Michael L. "Embodied Cognition: A Field Guide." *Artificial Intelligence*. Vol:149 No.1 (2003): 91-130.

[299] Ibid.

[300] Varela, Thompson and Rosch, *The Embodied Mind: Cognitive Science and Human Experience*.

[301] Ibid.

Considering the coupling of an agent with its environment through its sensorimotor capacities, Varela also conceives of cognition as an embodied action and states that:

> "By using the term "embodied" we mean to highlight two points: first, that cognition depends on the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing, biological, psychological, and cultural context."[302]

Embodiment of cognition have been formulated in various ways according to the field it is studied in such as; psychology, robotics, linguistics, and philosophy of mind, yet they all argue for embodiment as the necessary condition of cognition. The basic notion of embodiment is defined by Thelen as;

> "To say that cognition is embodied means that it arises from bodily interactions with the world. From this point of view, cognition depends on the kinds of experiences that come from having a body with particular perceptual and motor capacities that are inseparably linked and that together form the matrix within which memory, emotion, language, and all other aspects of life are meshed. The contemporary notion of embodied cognition stands in contrast to the prevailing cognitivist stance which sees the mind as a device to manipulate symbols and thus concerned with the formal rules and processes by which the symbols appropriately represent the world."[303]

Emphasizing the role of couplings between mind, body and environment, and their influences on one another, embodied cognitivism provides explanations of

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[302] Ibid.

[303] Thelen, Esther, Schoner, Gregor, Scheier, Christian, and Smith, Linda B. "The Dynamics of Embodiment: A Field Theory of Infant Perservative Reaching." *Behavioral and Brain Sciences*. Vol.24 No.1 (2001): 1-34.

these couplings and their influences on one another. The point here is that the couplings affect the perception of the environment and the development of cognitive processes executed by the agent. Varela states that "cognition is not the representation of a pre-given world by a pre-given mind but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs."[304] Therefore, it can be claimed that the way the agent is embodied in the environment both affects the interaction with and the perception of the environment. Accordingly, the way an agent experiences the environment and the world is in direct relation with the particular type of embodiment and bodily characteristics of the agent.

On the other hand, considering that sensorimotor capacities influence the experience of the agent, it can be asserted that an agent's experience of the environment and the knowledge constructed as consequences of interactions depend on his/her experiences. According to Varela, when one of the sensorimotor capacities is impaired, the experience of the environment is also affected since their coupling and interaction influence the perception and experience of the agent.[305] Varela states that perception is in active exchange with other sensory modalities.[306] He highlights that these modalities influence one another and claims that impairment of one modality affects the other as well.[307] In Varela's approach the neural network functioning in perceptions is not considered as a directional structure from perception to action, but rather, is considered as a complex structure where "perception and action, sensorium and motorium are linked together."[308]

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[304] Varela, Thompson and Rosch, *The Embodied Mind: Cognitive Science and Human Experience*, 9.

[305] Ibid, 164.

[306] Ibid, 163.

[307] Ibid.

[308] Ibid.

Based on these statements, it is possible to compare embodied cognition and cognitivism. The main distinction between them is the consideration of couplings and the environment. Although embodied cognition focuses primarily on the couplings of mind, body and environment together with the interplays between them to understand the cognitive processes and also the construction of perception, cognitivism takes into account neither the couplings nor the embodiment in its definition of the cognitive processes. In this sense, the cognitivist stance provides for an isolationalist analysis, where cognition is defined as an internal mental process. Another important distinction between embodied cognition and cognitivism is that cognitivism considers cognition as a passive retrieval that is encoded through direct representations of the physical environment, whereas in embodied cognition, it is viewed as a constructive and active process based on the agents' embodied experiences and sensorimotor capacities.

These differences in the theoretical perspectives on cognition promise a base for a shift in the conception of cognitive processes. In the experienced shift, interaction with the environment is considered as the fundamental condition of cognition, where the material and social structures are continually renegotiated with interactions and defined as elements of cognitive systems and activities.

3.2.5.2 Extended Mind

Extended mind signifies the departure from the Cartesian concept of cognition that is affected from the discussions on the mind-body relationship, and from the debates on embodied cognition.[309] The theory of the extended mind is one of the views which assert that cognitive processes embrace elements beyond the boundary of the human organism. [310] It opposes the Cartesian concept of

[309] Rupert, Robert D. *Cognitive Systems and the Extended Mind* (New York: Oxford University Press, 2010).

[310] Ibid.

the human mind and challenges the notion that mind and cognition are purely internal phenomena.[311] According to this theory, the parts, which are external to the agent's body, can act as material media for the agent's mind and can be viewed as parts of the mind. In this sense, the theory of mind that extends the body thoroughly opposes the traditional mind-body split.

The concept of the extended mind is introduced in 1998 by Andy Clark and David Chalmers in an article titled "Extended Mind," where they discuss the philosophy of mind and argue for the liberation from the conception of cognition as happening only in mental space. This view supports the idea that the human mind cannot be considered as the product of the brain.[312] The concept of the extended mind asserts that the boundaries of the human mind may extend the biological boundaries of the brain.[313] Opposing the cognitivist stances, the claim of this view is that the human mind may extend beyond the brain to cover a much larger network of neural resources.

The extended mind discussion in Clark and Chalmers' article refers to the division between the mind and the environment by stating that as a consequence of the couplings performed, some objects in the external environment can be regarded as extensions of the mind.[314] From their point of view, the mind performs cognitive processes that are not restricted with the boundaries of the brain.[315] According to Clark and Chalmers' view, the boundaries of the mind can be extended related with the issue of cognitive

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[311] Ibid.

[312] Clark, Andy and David Chalmers. "The Extended Mind." Analysis. Vol. 58 No.1 (1998): 7-19.

[313] Ibid.

[314] Ibid.

[315] Ibid.

function.[316] They suggest a unified condition of the environment with the cognitive processes and argue for the symbiotic relationship between the cognitive system and the human consciousness.[317]In this symbiotic relationship, the external factors create a coupling with the cognitive processes, which may extend the confines of the human brain.

The external factors and entities creating the coupling with the human are argued to affect cognition and are actively involved in the definition of the cognitive process. Considering these couplings, Clark and Chalmers state that;

> "In these cases, the human organism is linked with an external entity in a two-way interaction, creating a *coupled system* that can be seen as a cognitive system in its own right. All the components in the system play an active causal role, and they jointly govern behavior in the same sort of way that cognition usually does. If we remove the external component, the system's behavioral competence will drop, just as it would if we removed part of its brain. Our thesis is that this sort of coupled process counts equally well as a cognitive process, whether or not it is wholly in the head."[318]

In these couplings, the external features and/or the objects within the environment are asserted to play a crucial role in the cognitive process and also in the behavior of the human. These couplings are asserted to define an "active externalism" in the cognitive processes.[319] It is believed that by embracing the

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[316] Ibid.

[317] Ibid.

[318] Ibid.

[319] According to Clark and Chalmers active externalism opposes the passive configuration advocated by Putnam (Putnam, H. The meaning of `meaning'. In (K. Gunderson, ed) Language, Mind, and Knowledge. Minneapolis: University of Minnesota Press. 1975) and Burge (Burge, T. Individualism and the mental. Midwest Studies in Philosophy. No.4. 1979. Pp.73-122.). Clark and Chalmers describe Putnam's and Burge's positions as "passive" because, as they put it:

"When I believe that water is wet and my twin believes that twin water is wet, the external features responsible for the difference in our beliefs are distal and historical, at the other end of active externalist view, it becomes possible to explain the extended cognitive processes composed of a series of inputs and actions without complex explanations.[320] Clark and Chalmers give the example of the Scrabble to consider one's choice of words as an extended cognitive process and identify the re-arrangement of tiles on the tray not as part of action but rather as part of thought.[321] Therefore, according to Clark and Chalmers, the external objects that function as internal processes can be considered as part of an extended cognitive system.

In view of these claims, Clark and Chalmers not only take into account the extension of cognitive processes into the environment but also highlight that external factors can make a significant contribution to mental states. In order to support their argument, they provide a thought experiment in "The Extended Mind" article and try to illustrate the role of environment and external factors on the mind and cognitive processes. They provide two characters Otto and Igna, who are both trying to reach a target, the museum.[322] Otto is defined as having Alzheimer's disease and writing down the directions in a notebook, which serves as memory for him.[323] Although both characters are assumed to

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a lengthy causal chain. Features of the present are not relevant: if I happen to be surrounded by XYZ right now (maybe I have teleported to Twin Earth), my beliefs still concern standard water, because of my history. In these cases, the relevant external features are passive. Because of their distal nature, they play no role in driving the cognitive process in the here-and-now. This is reflected by the fact that the actions performed by me and my twin are physically indistinguishable, despite our external differences.

In the cases we describe, by contrast, the relevant external features are active, playing a crucial role in the here-and-now. Because they are coupled with the human organism, they have a direct impact on the organism and on its behavior. In these cases, the relevant parts of the world are in the loop, not dangling at the other end of a long causal chain. Concentrating on this sort of coupling leads us to an active externalism, as opposed to the passive externalism of Putnam and Burge."

[320] Ibid.

[321] Ibid.

[322] Ibid.

[323] Ibid.

have had a belief of the location of the museum, Igna's memory is internally processed by the brain, whereas Otto's memory is externally processed by the notebook.[324] In reference to this example, Clark and Chalmers state that Otto's mind has been extended to the notebook that served as the source of memory.[325] Through this example, they clarify that the mind should not be bounded by the brain and can be extended to the environment. This example also illustrates that the coupling between the human mind and the environment, may result in cognitive processes. Therefore, no matter whether it is internal or external to the body, if an object in the environment plays the same role with the object located in the head, it can still be counted as part of a cognitive system. The information related with the location of the museum in Inga's mind and the information in Otto's notebook act in the same manner and they are both counted as parts of the cognitive system.

The concept of extended mind has been interpreted in different fields to include the processes that consider the distributed or extended human cognition. As we move into an era of pervasive computing and ubiquitous network access, the environment becomes infused with computational potential and the possibilities for extending the mind increase. With the introduction of new design tools, strategies, materials, and machines, the permeable capacity of the boundary between the human and the environment increases and different ways of extending the mind and couplings between mind, body, environment and machine emerge.

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[324] Ibid.

[325] Ibid.

3.3 Mapping the Body in Responsive Environments and the Deleuzian Body

The responsiveness of the environment that makes use of technological advances such as ubiquitous computing, sensor systems, smart materials and textiles can offer new potentials for the definition and experience of the body and embodiment. These environments call for the contribution of the humans to the definition, transformation and experience of the environment and enable its user to project themselves on the environment in different ways.

In a responsive environment the body can be re-conceptualized so as to enable this contribution and projection and be continuously triggered by the environment or the bodies involved in the environment including himself/herself. Through the non-linear feedback loop enabling the responsiveness of the environment the human participant can experience the outcomes of his/her contribution to the environment, its impacts on the environment and also on the other participants. Embodiment is transformed as the relations are triggered and altered during interaction. In order to understand how the body and its embodiment transform in responsive environments a closer look at Deleuze needs first to be provided.

According to Deleuze, the body should always be triggered so as to see the challenges it contains.[326] In his definition of the body, Deleuze refers to Spinoza, who describes the body as something dynamic whose limits and capacities can be revealed through ongoing interactions.[327] Spinoza identifies the body in two ways and states that:

> "In the first place, a body however small it may be, is composed of an infinite number of particles; it is the relations of motion and rest, of speeds and slownesses between

[326] Deleuze, *Spinoza, Practical Philosophy*.

[327] Ibid.

> particles, that define a body, the individuality of a body. Secondly, a body affects other bodies, or is affected by other bodies; it is this capacity for affecting and being affected that also defines a body in its individuality."[328]

Deleuze names the first proposition for the body provided by Spinoza as the 'kinetic proposition' or the 'longitude' of the body and states that it entails the relations of rest and movement, of speed and slowness with the particles of the individual body.[329] Deleuze designates the second definition, which is considered to be the capacity for affecting and being affected, as the 'dynamic proposition' and the 'latitude' of the body.[330] He clarifies that, the particles in Spinoza's definition refer to the individuality of the body and its "unformed elements", whereas the affects refer to the relations of the body with other bodies or circumstances, an intensive and "anonymous force".[331]

In relation to the definitions provided by Spinoza, Deleuze considers the body as a composition of relations and states that; "a body can be anything; it can be an animal, a body of sounds, a mind or an idea; it can be a linguistic corpus, a social body, a collectivity" which can be conceptualized as an "assemblage of forces or affects disturbed on a plane of immanence."[332] Referring to the second proposition provided by Spinoza, Deleuze claims that any transition a body experiences also defines a change in the capacity to affect and be affected.[333] Gilles Deleuze puts it very clearly in the following quote:

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[328] Ibid, 123.

[329] Ibid, 122-130.

[330] Ibid, 127.

[331] Ibid.

[332] Ibid.

[333] Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 287.

> "A body is not defined by the form that determines it nor as a determinate substance of subject nor by the organs it possesses or the functions it fulfills. (On the plane of consistency), a body is defined (only by a longitude and a latitude: in other words) by the sum total of the material elements belonging to it under given relations of movement and rest, speed and slowness (longitude); the sum total of the intensive affects it is capable of at a given power or degree of potential (latitude). Nothing but affects and local movements."[334]

The picture Deleuze provides of the body as a composition and articulation of relations that affects and is affected by other bodies is essential in understanding the changes introduced by responsive environments, since it is possible to trace a similar definition of the body in responsive environments.

The body in a responsive environment cannot be considered in its mere physical being but also in the relations it provides and triggers. Responsive environments reveal in their relationship with the environment and other bodies the Deleuzian conception of the body. This conception does not prioritize the human body over other non-human bodies, nor distinguishes living from non-living. The Deleuzian philosophy of the subject where the subject is not considered as a central and static structure, but instead thought as an ever-evolving substance, decenters anthropocentric conceptions of the human and the environment, since the human body is not distinguished as a prioritized and separate body from the other bodies or the environment. Decentralization of the human indicates the dissolution of anthropocentrism and hence raises the consideration of the post-humanist context, which initiates the dissolution of dichotomies between subject and object, as well as between human and non-human.

[334] Ibid.

Responsive environments, which operate with machinic approaches put emphasis on the dynamic interactive processes and initiate the emergence of the body and the embodied experience through the relations defined in the dynamic interaction process. In machinic approaches, the environment is also considered as a body together with other non-human entities. The interlace of the body with the responsive environment that is equipped with aforementioned technological advances such as ubiquitous computing, new materials and textiles, sensor-network systems etc., can be considered as defining a change in the conception of body and also of embodiment, where the former is not bounded with the skin but rather extended into the environment. The extension of bodies is enabled with the inclusion of the relations in the definition of the embodiment, which are never separable from the bodies. The relations are transformed continuously and the embodiment of these relations alters relatively, which in turn affects both the relations and the bodies.

Responsive environments provide for a simultaneous production of artifacts, assemblages, multiplicities and desires which can force the human participant to realize the dynamic and fluctuating boundaries of his/her body, hence introducing new experiences of the body and conditions of embodiment.[335] The mutual dependency between the participants of the environment introduces a new concept of the body as emerging from the interactions between the human, the machine, and the environment. The Deleuzian philosophy of the subject calls for a dissolution of dichotomies between mind and body, machine and human, but also between subject and object.

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[335] Hayles, K. "Flesh and Metal: Reconfiguring the Mindbody in Virtual Environments," Configurations. Vol. 10 No 2 (Spring. 2002): 297-320.

3.3.1 Alterations in Subject-Object Conditions

The subject-object dichotomy, a longstanding philosophical issue dating back to Cartesian Dualism,[336] arises from the principle argument that "the world consists of entities, which exist 'out there,' beyond the internal world of human subjects" and considered that these entities are perceived by observers.[337] In the dialectics, the entities are regarded as objects, where the observers are regarded as subjects.[338] In other words, the subject is considered as an observer, where the object is considered as being observed by the subject.

In philosophy, a subject is defined as having a subjective experience through the relationship it posits with another entity/object.[339] The Cartesian separation between subject and object corresponds to the distinction in Descartes' philosophy of mind, where mind and body are defined as separate substances. As it has been discussed previously, Descartes believed that thought (subjectivity) was the essence of the mind, and that extension (the occupation of space) was the essence of matter. [340] Starting with Descartes' theory, the subject that thinks, perceives, judges, agrees, disagrees, loves, hates, strives, and likes is considered to have a priority over the object.[341] In Descartes' theory of subject-object distinction, although the subject is considered as a thinking thing, the object is considered as an extended thing, which cannot

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[336] Guignon, Charles. *Heidegger and the Problem of Knowledge* (Indianapolis, Ind.: Hackett Pub. Co., 1983).

[337] Jones, Andrew. Archaeological Theory and Scientific Practice. Cambridge; New York: Cambridge University Press, 2002.

[338] Jones, Andrew. *Archaeological Theory and Scientific Practice* (Cambridge; New York: Cambridge University Press, 2002).

[339] Wright, Georg Henrik. In the Shadow of Descartes: Essays in the Philosophy of Mind (Dordrecht; Boston: Kluwer Academic Publishers, 1998).

[340] Descartes, *Discourse on Method and the Meditations*.

[341] Gibbs, *Embodiment and Cognitive Science*, 4.

think.[342] According to this independent relation between the subject and the object, the subject is considered as an active substance that observes the object, upon which it acts. The object, on the other hand, is believed to express its essence or existence when acknowledged by the subject.

In early twentieth-century philosophy, the established relations between the subject and object have been attempted to be redefined. Heidegger puts one of the strongest criticisms of the Cartesian subject-object relationship in his work "Being and Time,"[343] where he rejects the subject-object distinction and introduces the concept of *Dasein*, "being-in-the-world."[344] In his existential analytic of *Dasein*, Heidegger tries to liberate the subject from its Cartesian interpretation.[345]There are also other philosophers, who attacked the subject-object relationship as proposed in the Cartesian approach, such as John Dewey, Charles Sanders Peirce and William James.[346] The critics provided by these pragmatist philosophers concentrate mainly on the passive condition of the subject in the conventional subject-object model.[347] They highlight that the subject, even when passive, can engage in process through sensory

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342 Descartes, *Discourse on Method and the Meditations*.

343 Heidegger, Martin. *Being and Time* (Albany, NY: State University of New York Press, 1996).

344 Ibid.

345 Ibid.

346 Detailed information about these philosopher's views on subject-object relationship can be traced through the following references;

James, William. The Writings of William James: A Comprehensive Edition. Chicago: Universityof Chicago Press. 1977.

Dewey, John. Dewey on Experience, Nature, and Freedom. Indianapolis: Bobbs-Merrill. 1960.

Peirce, Charles Sanders. The Collected Papers of Charles Sanders Peirce, Volume 1-6, Eds. Charles Hartshorne and Paul Weiss. Cambridge: Harvard University Press.

involvement.[348] Hence, the passive subject as observer can participate in the process and contribute to the production.

The continuous production of new connections, flows and interruptions in responsive environments is seen to call for a Deleuzian conception of the subject, which does not consider the subject as a counterpart to the object and hence provides for a powerful dislocation of the Cartesian subject. A fundamental part of Deleuze's philosophy of the subject is built upon his philosophy of difference and becoming.[349] According to Deleuze, the subject is always in the process of becoming and cannot be separated from its relations with the world.[350] The complex relations defined in the world provide a shifting ground of processes that affect the subject, which in turn affects other bodies.[351] The subject is not considered as a central and static structure, but instead thought as being in constant transformation and defining a non-hierarchic and non-centered state.

Taking into account these aspects, it can be asserted that responsive environments, provide the necessary conditions for the dissolution of the Cartesian subject-object dichotomy. The mutual interaction in responsive environments between the human and machine participants transcend the clear distinctions between the subject and the object. Although it is possible to find the traces of both conditions, subject and object are seen to merge into and transform each other, hence loosing their distinguishing characteristics.

The dissolution of this dichotomy will be traced in the cases discussed in the following chapter. But in order to understand how Deleuze's philosophy of

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[348] Ibid.

[349] Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 5-6.

[350] Deleuze, *Spinoza, Practical Philisophy*, 123.

[351] Ibid.

subject and body point towards the dissolution of dichotomies and an ever-evolving embodiment of extended bodies, his concepts of fold and rhizome need first to be traced.

3.3.2 Deleuze and the Fold

In various attempts at discussing the changes in the experience of body and embodiment introduced by the advances in interaction design and ubiquitous technologies, it is referred to Deleuze's definition of the fold. His conception of the body can assist the studies in understanding the changes defined through the extension of the body into the environment in responsive environments as well as the dissolution of dichotomies between inside and outside, human and machine, subject and object. Considered as an ontology of becoming and continuity rather than a technical device, the fold is defined as a population of many folds. Deleuze states that:

> "…thus a continuous labyrinth is not a line dissolving into independent points, as flowing sand might dissolve into grains, but resembles a sheet of paper divided into infinite folds or separated into bending movements, each one determined by the consistent or conspiring surrounding… A fold is always folded within a fold, like a cavern in a cavern. The unit of matter, the smallest element of the labyrinth, is the fold, not the point which is never a part, but a simple extremity of the line."[352]

Deleuze defines the fold as a degree of development and differences rather than a simple metric change. He further defines "unfolding" as a multiple of the foldinstead of considering it as its antonym and states that;

> "Folding-unfolding no longer simply means tension-release, contraction-dilation, but enveloping-developing, involution-evolution… The simplest way of stating the point is by

[352] Deleuze, Gilles. *The Fold: Leibniz and the Baroque* (London; New York: Continuum, 2006), 6.

> saying that to unfold is to increase, to grow; whereas to fold is to diminish, to reduce, to withdraw into the recesses of a world. Yet a simple metric change would not account for the difference between the organic and the inorganic, the machine and its motive force. It would fail to show that movement does not simply go from one greater or smaller part to another, but from fold to fold. When a part of a machine is still a machine, the smaller unit is not the same as the whole."[353]

The reflections of Deleuze's philosophy of the fold can be traced in continuously transforming environments, which are coupled with the advanced technologies such as nano-technology, smart materials, ubiquitous computing etc. When these environments are read in terms of Deleuze's definition of the fold and considered as having no beginning or end but rather defining an evolving continuum, the human body is considered as being expanded into the environment rather than separated from it. The merging of the human body and the technologically embraced environment initiates the folding of the human body with the environment and also its unfolding into the environment, which creates a continuum. The skin, which is the border of the human body, can lose its clear boundaries during this folding-unfolding process and become unfolded into the environment. Assessment of responsive environments by considering the philosophy of the fold brings with it the liberation from the concept of the body or the subject as being separated from the environment. On the contrary, this assessment embraces the extension of the body or the subject into the environment or even their defining/becoming the environment. The body is folding into the environment that is interlaced with the mentioned technologies, and these new technologies are refolding the embodiment of the relations, contexts and affects, where the human body can be altered in new ways.[354] In this altered experience, continuous folds are regarded as operative processes,

[353] Ibid, 9.

[354] Schick and Malmborg, "Unfolding and Refolding Embodiment into the Landscape of Ubiquitous Computing."

which regard the body as an ever-evolving body and do not assign priorities to the body over the others. These operative processes define an evolving process and enable the dissolution of the dichotomies through the extension of bodies into each other.

3.3.3 Rhizome

Deleuze's philosophy is seen to overcome the dichotomies between the subject and the object, where the subject is considered as inseparable from the environment that continuously transforms it. [355] In this dynamic and ever-evolving process the body is not considered as fixed and stable, but rather as a system of intersecting linear multiplicities.[356]

In Deleuze' philosophy, the body is recognized as a complex multiplicity and defined as a rhizome. Considered as having neither a beginning nor an end, a rhizome is defined as a state of growing, constituting linear multiplicities that have neither subject nor object.[357] Deleuze and Guattari summarize the principal characteristics of a rhizome as follows:

> "Unlike trees or their roots, the rhizome connects any points to any other point, and its traits are not necessarily linked to traits of the same nature; it brings into play very different regimes of signs, and even nonsign states. The rhizome is reducible neither to the One nor the multiple. It is not the One that becomes Two or even directly three, four, five, etc. It is not a multiple derived from the One, or to which One is added (n + 1). It is composed not of units but of dimensions, or rather directions in motion. It has neither beginning nor end, but always a middle (milieu) from which it grows and which it overspills. It constitutes linear multiplicities with n dimensions having neither subject nor object, which can be

[355] Deleuze, *Spinoza, Practical Philisophy*, 123.

[356] Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 8.

[357] Ibid.

> laid out on a plane of consistency, and from which the One is always subtracted (n - 1). When a multiplicity of this kind changes dimension, it necessarily changes in nature as well, undergoes a metamorphosis."[358]

In this definition, the body is neither considered as the sum of multiple parts, nor defined as a hierarchical configuration. Rather, it is defined as the counterpart to hierarchy. Acting like a configuration of connected points, which are independent nodes, a rhizome stands apart from centralization or hierarchical order. In this anti-hierarchic configuration, all nodes should be connected, where any node can be connected to any other point, while none of the nodes has priority over the others or come before another.[359]

Deleuze and Guattari's definition of the rhizome stems from the analysis of a tree structure, where they define it as contrasting the rhizome by representing a hierarchic order with roots, trunk, and branches. The rhizome does not have a beginning or an end, but made up of nodes connected to each other without any hierarchic order. The rhizomatic body is in a constant state of transformation: "an a-centered, nonhierarchical, non-signifying system without a General and without an organizing memory or central automation, defined solely by a circulation of states."[360] Deleuze and Guattari criticize the view that defines all the parts as growing from a tree, and state that this approach does not embrace the explanation of multiplicity. Contrasting with the tree, the rhizome does not have a single structure, from which all development occurs.

Deleuze and Guattari define a multiplicity as an assemblage of points defining a rhizomatic whole.[361] In the principle of multiplicity, the multiple is treated as

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[358] Ibid, 21.

[359] Ibid, 7.

[360] Ibid, 21.

[361] Ibid, 4.

substantive and the One as having no useful value except being a part of the many. Deleuze and Guattari state that:

> "It is only when the multiple is effectively treated as a substantive 'multiplicity,' that it ceases to have any relation to the One as subject or object, natural or spiritual reality, image, and world. Multiplicities are rhizomatic and expose arborescent pseudo-multiplicities for what they are. There is no unity to serve as a pivot in the object, or to divide in the subject. There is not even the unity to abort in the object or 'return' in the subject. A multiplicity has neither subject nor object, only determinations, magnitudes and dimensions that cannot increase in number without the multiplicity changing in nature."[362]

Deleuze and Guattari provide the example of puppet strings as a rhizome or multiplicity, where the puppet strings are connected to the 'multiplicity of nerve fibers' in the arms of the artist moving the puppet, which are in turn linked to the brain.[363] The brain is also considered as connected to another multiplicity; the multiplicity of neurons. This connection is defined as forming another puppet that is connected to the first. [364] Although these connections are in different dimensions, multiplicity increases through extending its connections to other multiplicities.[365]

Deleuze's concept of rhizome explained through multiplicity can guide the attempts at tracing the changes in the conditions of the subject and the object in responsive environments that also provide for such growing and evolving processes. Responsive environments, which facilitate the extension of the body into the environment through machines, also propose a non-hierarchic configuration. In these configurations, none of the bodies has priority over the

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[362] Ibid, 7-8.

[363] Ibid, 9.

[364] Ibid, 9.

[365] Ibid, 9.

other. They are all considered as nodes of multiplicity and hence connection of all nodes is satisfied.

In responsive environments, all the machine, human and non-human participants of the interaction are connected as nodes of a configuration without proposing a hierarchic order. They define an a-centered and non-hierarchical rhizomatic body. It is also a multiplicity, since the human or non-human participants having many multiplicities in themselves are connected to a responsive machine, which is a whole made up of a multiplicity of elements such as sensors, actuators, processors, cables, modems, digital cameras, etc.; hence, the whole configuration can be considered as a multiplicity within multiplicities. Therefore, when the responsive environment is defined as inheriting rhizomatic characteristics, the subject-object dichotomy dissolves into a blurred condition. Although, it is possible to detect attributions that reconstitute the subject condition during some instances of the process, clear differences between these two conditions can no more be sustained. The constant transformation enabled by the responsiveness of the environment and also by the responses of the human and machine participants of the process enable to start up the relations that provide for the necessary dynamic ground for the blurring of subject-object conditions.

3.3.4 Becoming-Body

The Deleuzian body has been said to be in continuous alteration. It is a production that is not defined in reference to something already in existence but rather according to the new productions it produces. [366] It is defined as a becoming, redefined in each change:

[366] Ibid, 237-238.

> "A becoming is not a correspondence between relations. But neither is it a resemblance, an imitation, or, at the limit, an identification ... To become is not to progress or regress along a series. Above all, becoming does not occur in the imagination, even when the imagination reaches the highest cosmic or dynamic level... They are perfectly real... Becoming produces nothing other than itself. We fall into a false alternative if we say that you either imitate or you are. What is real is the becoming itself, the block of becoming, not the supposedly fixed terms through which that which becomes passes." [367]

Deleuze and Guattari consider a becoming and multiplicity as inseparable and concomitant associations.[368] They do not consider becoming as a progress of evolution but rather define it regarding the associations between relations and in reference to multiplicity. In the principle of multiplicity, the entire multiplicity redefines itself whenever a dynamic of the multiplicity changes. The becoming-body is a temporary negotiation of multiplicities, which intersect in order to establish new connections with other multiplicities. Although it is defined as being composed of unlimited multiplicities, it is not the sum of its parts. It is an affect, a becoming, resulting from the temporary negotiations between multiplicities.

Although affect and effect are related, they offer oppositional characteristics. When Deleuze's definition of an affect is considered, it can be claimed that it is not possible to define a direct cause and effect relation in responsive environments which are defined by machines. An affect in a responsive environment can be defined to come into being when a connection or interaction is defined between bodies, which can be the environment or any human/non-human body. The body altered during the interaction process affects the other bodies, where it is in continuous transformation; the body is a becoming.

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[367] Ibid, 262.

[368] Ibid, 156.

The mechanisms used in the definition of responsiveness are seen to concentrate mainly on the effectiveness of the system. Deleuze's definition of affect as a becoming reveals the distinction between mechanisms and machines used in responsive environments. Contrary to the mechanisms, machines in responsive environments seek to define an affective machine or environment instead of an effective one. When the effectiveness of the mechanism is prioritized, there arises a danger of defining organized systems that respond in the same way to the stimuli from the bodies.[369] These organized and effective environments can homogenize the bodies and life and define a 'body with organs' as Deleuze and Guattari express it.[370] However, machines can overcome this organization and define affective and unorganized environments. Deleuze and Guattari suggest the conception of a Body Without Organs to overcome such organization and define a continuous production.[371]

3.3.5 Body without Organs (BwO)

The body as defined by Deleuze and Guattari is making new connections and couplings with other bodies to produce desire; a desire for production.[372] It is considered as a complex multiplicity of bodies, which are in continuous reterritorialization.[373] Resulting from continuous reterritorialization and production of desire, the bodies become what Deleuze and Guattari term a body without organs (BwO).[374] BwO is a limit, where flows flow into each

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[369] Schick, Lea and Malmborg, Lone. "Bodies, Embodiment and Ubiquitous Computing." *Digital Creativity*. Vol.21 No.1 (May 2010): 63-69.

[370] Ibid.

[371] Ibid.

[372] Deleuze and Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*, 6.

[373] Ibid, 34.

[374] Ibid, 38.

The term body without organs is borrowed from Antonin Artaud's radio play "*To Have Done with the Judgment of God,*" where the following quote is provided; *"When you will have made* other freely. However, flows are defined as not being free; they are always interrupted. In this respect, BwO is also a desire, a limit that is going to be achieved.

The body suffers from these new connections and flows, “from being organized in this way, from not having organized some other sort of organization, or no organization at all.”[375] BwO resist this need for organs and organisms. In this continuous negotiation, the body constantly struggles with bodies that produce flows, while at the same time attempting to achieve a BwO. However, the body cannot fully become a BwO, since the relationships and connections are continuously destabilized by the flows.[376] Deleuze and Guattari state that;

> “The body without organs is nonproductive; nonetheless it is produced, at a certain place and a certain time in the connective synthesis, as the identity of producing and the product: the schizophrenic table is a body without organs. The body without organs is not the proof of an original nothingness, nor is it what remains of a lost totality. Above all, it is not a projection; it has nothing whatsoever to do with the body itself, or with an image of the body. It is the body without an image. This imageless, organless body, the non-productive, exists right there where it is produced, in the third stage of the binary-linear series. It is perpetually reinserted into the process of production... The full body without organs belongs to the realm of anti-production; but yet another characteristic of the connective or productive synthesis is the fact that it couples production with anti-production, with an element of anti-production.”[377]

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him a body without organs, then you will have delivered him from all his automatic reactions and restored him to his true freedom.” (Artaud, Antonin. "To Have Done with the Judgment of God" *Antonin Artaud Selected Writings*. Ed. Susan Sontag. Berkeley, CA: University of California Press, 1976.)

[375] Ibid, 8-9

[376] Ibid, 12.

[377] Ibid, 8

The organless body described by Deleuze and Guattari in this definition refers to the lack of organization, where the body without organs resists organ machines with its surface. This surface acts as a barrier and defines unstructured, undifferentiated counter-flows to resist the linked, connected and interrupted flows of organ machines.[378] This definition alters the biological definition of the body with its organs inside, but rather considers it as being constituted by its exteriority; surface connections.[379] According to Deleuze and Guattari it is through the surface that BwO resists the 'linked, connected and interrupted flows' produced by organ machines and provides a counter flow to interrupt it.[380]

The BwO concept is discussed in relation to desiring-machines in the fourth chapter, where the contrasting points are highlighted between these two opposing but complementary concepts.

Going over the main points of Deleuze and Guattari's definition of the body, it can be stated that the body is in a permanent state of becoming, where it is redefined and renegotiated constantly. It changes continuously and defines new connections. The body is also rhizomatic and hence it is not hierarchically configured. Defined through a complex multiplicity, it is not defined as the sum of parts, where the parts are unified to define a whole. The body is an affect that results from the negotiations between multiplicities. The rhizomatic body is always trying to be unorganized and attempting to become a BwO.

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[378] Ibid, 9.

[379] Ibid, 12.

[380] Ibid, 9.

3.4 Reconsidering Embodiment within the Context of New Technologies

Expressions of the Deleuzian body can be traced in responsive environments, which enable the definition of the body as something dynamic and in continuous transformation. The technologically embraced milieu of responsive environments considers the body as being actively involved in the environment. In their close relationship it becomes difficult to distinguish where each party ends and the other begins in the ever-changing relations between the body and the environment.

This concept of body in continuous transformation can offer new insights for responsive environments, in terms of the interaction between the human and the machine as well as the embodiment of relations during the interaction process. The human-machine interaction in a responsive environment, where the machines define new relations during their interaction with other bodies and transform themselves constantly, enables the embodiment of the environment and the changing relations between the parties involved in the interaction process. These environments problematize embodiment as unstable and inseparable from the environment and enable its continuous transformation.

The new tendencies in ubiquitous computing, responsive mechanisms, and sensor-network technologies focus more on relations and context, hence offer the potential of challenging the body and the issue of embodiment. These approaches and technologies can provide the embodiment of relations and contexts in different ways and do not bound embodiment with a human or non-human body. Looking at how these new approaches offer new opportunities for altering the body and the concept of embodiment, it can be asserted that through these recent approaches, the human-machine interaction and the conception of the machine have been reconceptualized to embrace this transformation. This section discusses these new experiences introduced by ubiquitous and wearable technologies that extend the boundaries of body and enable the extension of the mind into the environment.

3.4.1 Interaction and Embodied Experiences

This thesis has highlighted that the definition of embodiment has been altered in responsive environments to take into account the relations, desires, contextual values and diversities of the participants and the environment. Rather than focusing on a single entity operating in close relation with the other in a static relationship, in the recent paradigm, it is focused on multiplicities of participants, relations, inputs etc. and new relations are defined between the environment, the human and the machine.

In the conception of embodiment, computational theories and technology play significant roles. The technological apparatuses can be considered as part of the environment, either embedded in the environment or exposed. Considering the contemporary research on responsive environments, it can be asserted that the embodiment of humans' interaction process within or with the environment gain importance. In this sense, it can be referred to the concept of embodied interaction, which is defined by Paul Dourish as "the interaction with computer systems that occupy the world, a world of physical and social reality, and that exploit this fact in how they interact with us."[381] Dourish considers the concept of embodied interaction as an approach for understanding the interaction between the human and the machine that promotes complex relationships. Highlighting the interaction between mind, body and environment, Dourish states that;

> "Embodiment, then, denotes not physical reality but participative status. When I talk of "embodied interaction", I

[381] Dourish, Paul. *Where the Action Is: The Foundations of Embodied Interaction* (Cambridge, Mass.: MIT Press, 2004).

> mean that interaction is an embodied phenomenon. It happens in the world, and that world (a physical world and a social world) lends form, substance and meaning to the interaction. Like the example of a conversation, interaction is embodied not merely in the fact that there is physical contact between real fingers and a solid, three dimensional mouse; it is embodied in the sense that its occasion within a setting and a set of specific circumstances gives it meaning and value. By implication, it loses both if removed from those circumstances again."[382]

Dourish proposes that the concept of embodied interaction can be acknowledged as an approach to describe the interaction process that incorporates the relationship of humans with the environment through the use of interactive mechanisms. He indicates that this approach recognizes the direct interaction of bodies with the environment; either physical or social environment.[383] The essential proposition in Dourish's approach is the conception of an occasion or a conversation as the embodiment of a specific circumstance. The human in a responsive environment can experience embodiment according to the specific circumstances generating the embodiment, even when there is no physical interaction between the human and the environment. According to Dourish, in the responsive milieu, the embodiment of relations or contexts can exceed the boundaries of the body and can be defined in various forms, besides the material form.

Another important discussion provided by Dourish is that, through embodied interaction where both parties define new information inputs by engaging in the interaction process, the active participation, perception and experience of the human participant gains importance. The reflections of this approach can be traced in responsive environments that promote direct interaction with the environment. This direct interaction is enabled with ubiquitous computing

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[382] Dourish, Paul. "Embodied Interaction: Exploring the Foundations of a New Approach to HCI."1999. http://www.dourish.com/publications.html. [Accessed: April, 2011].

[383] Ibid.

systems such as mixed reality, ambient intelligence, wearable computing, tangible computing, pervasive computing, etc.

Underlining the participatory status of embodiment, Dourish mentions three major ways in which embodiment is relevant for understanding the human interaction with computer technology. First, since interaction is closely connected to the context, the embodiment of interaction within the environment gains importance.[384] According to Dourish, embodiment is crucial in understanding the interaction between the mechanism and the human, as it determines how the parts will fit together.[385] Second, Dourish draws attention to the change in the focus, where the attention placed on context, details, specifics and actual cases brings together the consideration of activities and artifacts in concrete terms.[386] This change is asserted to lead to a concern about the way interaction is manifested in the interface.[387] Dourish proposes tangible and social computing as illustrating new manifestations by bringing together artifacts and interaction.[388] Third, it is claimed that these artifacts can offer different roles through their direct embodiment in the world. [389]

The statements of Dourish reveal the importance of relations, context and physical and social situations in the interaction between the human, the machine and the environment and also in the embodiment of this interaction. His explanations reveal the change in the conception of embodiment, where he underlines the inclusion of interaction in the embodiment of the relations between mind, body and environment.

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[384] Dourish, *Where the Action Is: The Foundations of Embodied Interaction*.

[385] Ibid.

[386] Ibid.

[387] Ibid.

[388] Ibid.

[389] Ibid.

3.4.2 Embodied Space and Ubiquitous Computing

Ubiquitous computing is one of the strategies together with pervasive computing, ambient intelligence, and wearable technologies that merge computation, embodiment and the environment. Mark Weiser's vision of ubiquitous computing defines its goal as "enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user."[390] Highlighting the importance of the integration of computational abilities into the environment, Weiser claims that technologies should be "weaved into the fabric of everyday life until they are indistinguishable from it." [391] These new tendencies of integrating computation within the environment can change the way humans interact with technology and also the way the body is included and redefined in the proposed concept.

In the current era of computation that is defined through new technologies, the body is refolded to actively participate in the environment. Although the relations between the body and the ubiquitous environment are not exposed in a perceivable manner and concealed in the physical surrounding, it can be seen that the body is taken into account as a participant of embodied space.

Referring to the future condition of ubiquitous computing, Weiser states that it is the network of technology embedded in the surrounding that enables the communication between parties of interaction.[392] It is difficult to conceive the location and the working principles of the embedded and invisible interface at first sight. In addition, since this interface is dissolved in the environment, it

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[390] Weiser, Mark."The Computer of the 21th Century." *Readings in Human-Computer Interaction: Toward the Year 2000.* San Francisco, Calif.: Morgan Kaufmann Publishers, 1995.

[391] Ibid.

[392] Weiser, Mark, Gold, Rich and Brown, John Seely. "The Origins of Ubiquitous Computing Research at PARC in the late 1980s," IBM Systems Journal Vol. 38 No.4 (December 1999): 636-639.

becomes difficult to differentiate when and who triggered the relations or which body(s) have participated in the experience created. With these properties, the embodied space with ubiquitous computing alters the initial examples of embodied space, where the array of sensors are perceptible and the working principles of interaction process are easy to grasp.

According to Hansen and Wamberg in this new type of embodiment, humans do not interface but rather interlace with technology: They state that in this altered experience "user and system are weaved together, thereby turning the digital interface into an interlace."[393] This interlace leads to an interplay between computing devices, bodies and environment (either physical or social) that unfolds and expands itself to the environment. Diffusion of computing devices in the environment enables the unfolding of the body into the environment. In this relationship, the body and the skin are considered to provoke the network of relations and commit new concepts of body, embodiment and participant.

These altered surroundings are referred as embodied spaces or embodied environments, where human experience and consciousness takes on material and spatial form.[394] Embodied space is presented as a model for understanding place through spatial orientation, movement, and language, where the body is conceived "as a physical entity, as a lived experience and as a center of agency."[395] In an embodied space, information from different parties of interaction and responses to information are interacted through the body to develop new experiences and spatial definitions. In these new experiences and

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[393] Hansen, Lone Koefoed and Wamberg, Jacob. "Interface or Interlace?: Or How Art Is Mediated in Augmented Reality." in *Digital Arts & Culture 2005 Conference: Digital Experience: Design, Aesthetics, Practice*. Proceedings, 161-169. Denmark, 2005.

[394] Low, Setha M. and Lawrence-Zúñiga, Denise. *The Anthropology of Space and Place: Locating Culture* (Malden, MA : Blackwell Pub., 2003).

[395] Ibid.

definitions, the body is seen not to act apart from the mind. Rather, both the environment and the experience are considered as dependent on the body that is not only affected by the environment but also affects the environment.

3.4.3 Shared Embodiment

In an environment that is responsive to the intended or unintended actions and changes in the environment, it is difficult to identify the relationship between actions and responses and to grasp the transformation in the conception of embodiment. It is also difficult to understand how these intricate relations have been triggered since the experiences of one party can be reflected on other parties and also on the environment, which in turn can define a non-linear feedback loop:[396] "In the environment of ubiquitous computing and sensor-network systems embodiment is always to be understood as a relational and rhizomatic feedback loop between a variety of factors including both humans and the richly designed and interconnected technological environment."[397]

In this reciprocal connection, the embodiment of relations is shared by the body, the environment, and the computational devices. Stating that humans are interwoven in the landscape of technologies, Schick and Malmborg consider that this type of embodiment is an embodiment of relations -a dynamic process actualized through interactions with the environment- and entitle it as "distributed and shared embodiment."[398] Schick and Malmborg state that;

> "Where the body and embodiment traditionally has been perceived as a centralized entity, our actions and body now become distributed throughout the environment and other

[396] Schick and Malmborg, "Unfolding and Refolding Embodiment into the Landscape of Ubiquitous Computing."

[397] Ibid.

[398] Ibid.

> bodies. Embodiment transforms and evolves as we move around. We are not isolated bodies or subjects, but become interwoven in each other and in the interactive landscape of technologies. This is an embodiment of relations, a dynamic process actualized through interactions with the environment. This is the concept of distributed and shared embodiment, as we have proposed."[399]

Parties in the environment react to each other and extend their responses to the environment and finally share the embodied experience with other bodies involved in the process. The shared embodiment is considered as an altered state of the body and embodiment, since it is affected by the interactions and changes in the environment.

The interwoven technologies, the notion of shared embodiment and the tendency to refold the body can dissolve the clear boundaries between human and non-human, mind and body, subject and object. Through the shared embodiment, the Cartesian distinction of subject and object is also to be redefined to experience the dynamic and ever-changing boundaries of the body.[400] Thereby, through the aforementioned approaches to body and embodiment, the subject-object dichotomy dissolves significantly.

The ubiquity and accessibility of the computing devices enable the closer interaction of the body with the environment, where they can be reflected on each other. This reflection and the interaction between the parties of communication can be embodied through the technological environment, where the relations and hence their embodiment transforms in relation to the interaction. Wearability of the computing devices and the use of smart materials can be considered as a way of attaining this dynamic process, where they manage the correlation of the relations with the body and the environment.

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[399] Ibid.

[400] Ibid.

3.4.4 Wearable Computing and Smart Materials

The common use of wireless communication techniques together with the miniaturization of computing devices affect the studies on human-computer interaction and stimulate the personalization of interaction and computing. Together with these advances, studies in ubiquitous computing and the shift from simulation to augmentation also stimulate the search for new types of interaction and computation, one of which being wearable computers/computing. Barfield and Caudell define a wearable computer as a "fully functional, self-powered, self-contained computer that is worn on the body.... [and] provides access to information, and interaction with information, anywhere and at anytime."[401] Worn on the body, a wearable computer acts like a personal computer (information processing agency) and provides information to the user, while the body is being actively engaged in the physical environment. Through the computational support it provides, wearable computers enable access to information and facilitate connectivity with the others parties of the networked connection. Accordingly, they offer increased information-processing abilities, and enable control over the environment or the body.[402]

The wearable computer either worn externally as clothing or embedded into the user's clothes can be considered as a second skin for the human. This second skin enables computational ability, physical and cognitive augmentation. As a consequence of the fluid relation between the computer and the user, the wearable devices can respond to the changing physical environment and also to the user's milieu. Through adapting the behaviors, the computers embedded in the second skin assist the user, provide feedbacks, and define an interlaced

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[401] Barfield and Caudell, *Fundamentals of Wearable Computers and Augumented Reality*.

[402] Dwinght Holland, Dawn J. Roberson and Woodrow Barfield. "Computing Under the Skin." *Fundamentals of Wearable Computers and Augmented Reality*. (NJ: Lawrence Erlbaum Associates, 2001).

relationship between the parties of interaction. Therefore, wearable computers can be considered as a second skin that enables the interaction between the human body and the responsive environment.

The coupling of the human body with wearable computers can be considered as leading to a new type of augmentation; bodily augmentation.[403] According to Barfield and Caudell, wearable computers enable personal empowerment by surrounding the human's personal space with added capabilities and present the possibility of augmenting the human body's sensory and cognitive abilities.[404] In this augmentation, the body is extended physically and participates in the definition of new type of relations, where it hosts the symbiotic compositions between itself, the environment, and the computer.

Within the current research on wearable computers, one of the ultimate goals is to define a more proactive relationship between the computer and the human. This relationship is expected to trigger the experiences of the user and enable the responsiveness of the body to the networked conditions of interaction and to the feedback loops. This relationship brings together a shift in the conception of the computer, where it is fused in the body and the environment and acts like their extension. Through this shift, both the body and the wearable computer can become a part of the information loop defined between the parties of interaction. As a reflection of this approach, it can be argued that wearable computers can enable the engagement of the human participant with the environment and alter his/her experience of the environment. It is also possible to state that the use of wearable computers affords new forms of information processing and presentation by combining technology with materials and textiles.

[403] Ibid.

[404] Ibid.

The main motivation of this new relationship between body and environment has three primary goals; to access, manage, and redefine information. The main question that this thesis deals with is not the technology enabling this engagement but rather the motivation and reflections of this engagement on the conception of embodiment and human machine interaction.

The initial expressions of these motivations can be traced in medical and military tasks, where the information gathered from the human is directly reflected on the information loop between the computer, human, and the environment. Another expression of these motivations can be traced in the use of smart materials and textiles, where the embedded computing fibers process and respond to the information gathered from the body or the environment.

In wearable computers as clothes, it is also possible to outline the motivation towards the responsive and participatory design, where the information traced from the human or the environment can actively contribute to the definition of the environment, its experience, and also representation. Wearable computers increase the expressive abilities of clothing, through responsive and reconfigurable components and update its representation according to the information input gathered from the human, environment or another party involved in the interaction.[405]The use of wearable computers as clothes also enables the personalization and expression of scanned information. These expressions can be numerical or visual expressions and define a new type of skin for each specific condition or person. Through the interplay of these properties, and technologies and design approaches, wearable computers as clothing can open up new ways of defining spatial experiences while altering the interpretation of responsiveness and responsive environments. Therefore,

[405] Mura,Gökhan. "Wearable Technologies for Emotion Communication." *Metu Journal of the Faculty of Architecture*. METU: Ankara. Vol. 25 No. 1 (2008):153-161.

the use of advanced technologies, wireless communication techniques and the miniaturized computing devices define new ways of self-expression. [406]

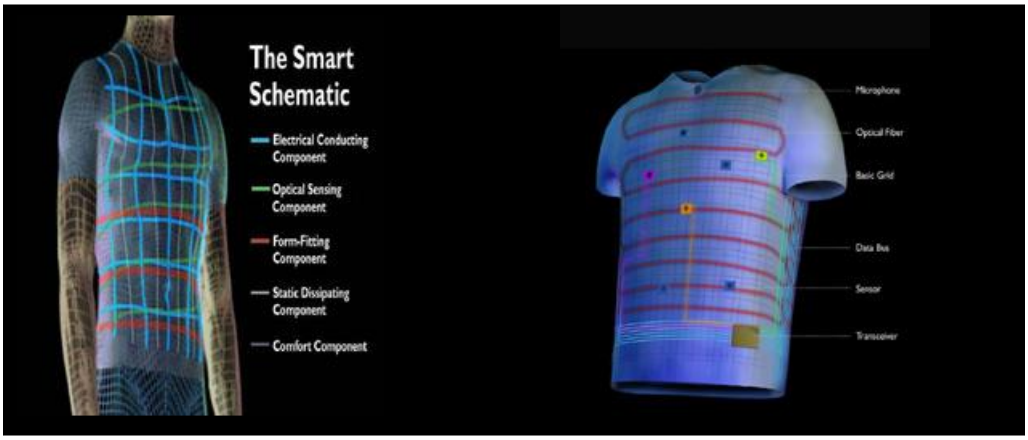

Figure 19: Smartshirt designed by Sensatex.

Source: Sensatex. http://www.sensatex.com/. [Accessed: April, 2011].

An example of wearable computers demonstrating how computation can be incorporated into fabrics and clothes is Sensatex's *Smartshirt* project (figure 19). The main motivation of this project is to propose a shirt that "thinks".[407] *Smartshirt* measures and monitors information for different purposes such as; maintaining a healthy lifestyle, health care, and occupational and public safety (i.e., security).[408] *Smartshirt* makes use of wireless communication capabilities and sensors to monitor signs and data from the human body (such as heart rate, body temperature, neural activity and respiration rate) through readouts, PDA or voice. The changes in the physiology of the human can be grasped easily and hence awareness can be provided about the changes in the physiological

[406] Campbell, Christopher, Chan, Denise M. and Miner, Cameron S. "Digital Jewellery: Wearable Technology for Everyday Life." in *Conference on Human Factors in Computing Systems*. Proceedings, 45-46. Washington, 2001.

[407] Sensatex. http://www.sensatex.com/. [Accessed: April, 2011].

[408] Ibid.

condition of the human and also in the relationships defined between the human body and the environment.

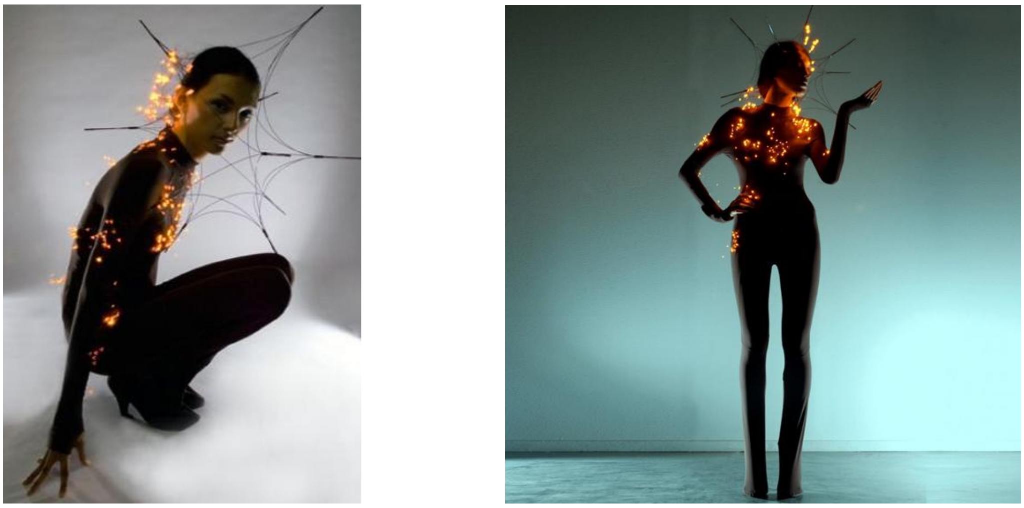

Figure 20: Frisson designed by Philips.

Source: Science Ahead. http://www.scienceahead.com/page/36/. [Accessed: April, 2011].

Another example is the *Frisson* project designed by Philips (figure 20), which is a body suit covered with hair-like sensors capable of grasping physical stimuli from the body like a breeze through emitting twinkling lights as a response.[409] It contains LEDs, which respond to the air movement upon the body and create visual outputs.

Contemporary applications of wearable computers and the expansive use of biometric sensors such as pulse-sensors, radio-frequency-sensors, galvanic skin response-sensors, thermo-measuring-sensors, tilt sensors, skin conductance-sensors, respiration sensors etc., as integrated into the textiles and clothes enable the conception of the body as part of the environment, perception, experience and cognitive processes and its active participation in the process.

[409] Science Ahead. http://www.scienceahead.com/page/36/. [Accessed: April, 2011].

The interest in the use of wearable computers facilitates the extension of the body into the environment and alters the experience of embodiment.

In this chapter, debates in the philosophy of mind and several significant conceptions of mind-body relationship have been traced, with an aim to reveal the problematization of the body and embodiment in responsive environments. The roots of this problematization are searched in the philosophy of mind and in the mind-body problematic, where it has been referred to cognitive science and the existing literature on the philosophy of mind and mind-body relationship. The mind-body relationship has been traced in relation to dualism and monism, behaviorism and cognitivism, where the distinctions between these approaches have been put forth. As a significantly different approach to body and embodiment it has been referred to Deleuze's definitions of body and subject, delineated in his concepts of fold, rhizome, becoming body and body without organs.

Deleuze's definition of the body and the subject are regarded as the main guidelines for understanding the distortion in these very concepts, that of embodiment and hence the human machine interaction in responsive environments. In order to understand these distortions and the conception of an unstable and changing body, which is inseparable from the environment and not bounded with one's (including humans and non-humans) body, Deleuze's definition of body and embodiment have been discussed. This discussion is associated with several approaches to extend the human body into the environment through the new technologies such as smart and responsive textiles and sensor-network systems, and ubiquitous computing. This chapter questioned, how the reconceptualization of the body enabled through these technologies defines new configurations of embodiment and mind-body relations and blurs the dichotomies between man and machine, human and non-human, subject and object.

In the following chapter, it is mainly concentrated on machines and machinic approaches embraced in the definition of responsive environments. The discussions in the fourth chapter expose the distortions in the human–machine interaction, where both are considered as bodies affecting each other, and the ways this interaction defines altered experiences of embodiment, blurs the subject-object dichotomy and changes the relation of the human with reality.

CHAPTER 4

MACHINES AND HUMAN-MACHINE INTERACTION

This chapter discusses the concept of the machine and the machinic approaches that are embraced to attain the responsiveness of the environment through machine participants. The machine has commonly been conceived as an agent of production and efficiency, expected to accomplish the required work effectively. The machine is so arranged that by means of its parts, which are closely related to each other, it can work in accordance with the physical world through apparent laws and principles.[410] This concept of machine implies the definition of a mechanism and hence initiates a mechanistic approach. However, a machine can make new connections with other machines, transform itself and also the other machines through these connections and define a continuously transforming interaction process.[411] This conception of the machine, associated with Deleuze's definition of the body and the machine, is the one at work in machinic approaches. These two different concepts of machine are regarded as corresponding to different approaches and are to be differentiated from each other.

This chapter mainly concentrates on Deleuze's definition of the machine and tries to reveal the association of his definition with the machinic approaches used in responsive environments. The changes in the conception of body and machine are discussed in relation to Deleuze, which includes references to his

[410] Reuleaux, *The Kinematics of Machinery: Outlines of a Theory of Machines*.

[411] May, Todd. *Gilles Deleuze: An Introduction* (New York: Cambridge University Press, 2005).

philosophy of the body. Emphasizing the blurred dichotomies between man-machine, subject-object and human-non-human that are introduced through machinic approaches, the emerging transformations in the conception of human-machine interaction and its re-conceptualization in responsive environments are put forth in this chapter. These approaches are considered as disturbing the human's relationship with reality and altering the conception of body and embodiment while enabling the synchronization of the body with the machine.

These re-conceptualizations are considered as potentials for altering the concept of responsiveness and the definition of responsive environments. In order to discuss the relation between responsive environments, machinic approaches and the re-problematization of embodiment and human-machine interaction in responsive environments, this chapter introduces different concepts of machines; desiring machines, bachelor machines and schizoid machines. Reflections of the machinic approach on the responsive environment are discussed in reference to four projects to reveal the specific experimentations embraced in these projects; *Olzweg* and *An architecture "des humeurs"* projects by R&Sie(n), *SYS*017.ReR*06/PiG-EqN\5*8* by Mathieu Briand and *Hormonorium* by Jean-Gilles Decosterd and Philippe Rahm. The transformations defined through the machinic approaches are associated with the debate on these approaches and their reflections in the conceptualization of responsive environments. In this respect, this chapter discusses the re-conceptualization of the human-machine interaction, the disturbance of the relationship with reality and significant methodological changes experienced correspondingly in the architectural design process.

4.1 Different Concepts of Machines

In this section, three different concepts of machine are introduced, that clarify the references to the machine concept embraced in responsive environments;

such machines are re-problematizing the questions of embodiment and human-machine interaction so that the relations between the bodies involved in the interaction are in continuous transformation. This concept of machine is considered as a manifestation of Deleuze's definition of the machine. In order to assess how these machinic approaches define the responsiveness of the environment and re-problematize embodiment and human-machine interaction, it is tried to reflect the debate on machines by focusing on three significant species; desiring-machines, bachelor machines and schizoid machines.

4.1.1 Deleuze and the Machine

The concept of machine as opposed to mechanism runs through the consideration of Deleuze and Guattari's definition of the machine. Their discussion introduces an unconventional conception of the machine, which alters the definition of machinic approaches significantly. According to Deleuze and Guattari, a machine is defined by the connections and productions it makes and is in a constant process of deterritorialization, or becoming other than itself.[412]

In *Anti-Oedipus: Capitalism and Schizophrenia*, Deleuze and Guattari use the terminology of machines, assemblages, connections and production, where the distinctions between machine and mechanism, machinic and mechanic are underlined.[413] They define a mechanism as a self-enclosed movement that works steadily and never transforms itself or produces new connections.[414] A mechanism is a closed machine that has a specific function. A closed machine is considered as a self-contained organism like the human body or an efficiently functioning clock mechanism. Similarly, an organism is defined as a

[412] Colebrook, *Gilles Deleuze*, 56.

[413] Deleuze and Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*.

[414] Ibid, 67.

bounded whole with an identity and an end. These closed machines are considered as illusions of machines: they are mechanisms.[415] A machine, for Deleuze and Guattari does not have a closed identity like a mechanism. It does not produce something determined by someone, but rather produces for the sake of production itself. [416]

While connecting and reconnecting to different machine(s), the machine evolves and mutates.[417] Colebrook exemplifies Deleuze and Guattari's definition of the machine in connection with other machines with the bicycle case:

> "Think of a bicycle, which obviously has no "end" or intention. It only works when it is connected with another "machine" such as the human body; and the production of these two machines can only be achieved through connection. The human body becomes a cyclist in connecting with the machine; the cycle becomes a vehicle. But we could imagine different connections producing different machines. The cycle becomes an art object when placed in a gallery; the human body becomes an "artist" when connected with a paintbrush."[418]

Therefore, a 'machinic becoming' makes a connection with another machine in order to transform and maximize itself. Machinic thinking recognizes these transformations and produces new connections and relations.[419] Deleuze and Guattari consider life as a machine. [420] They define all aspects of life as a machinic becoming, since they state that all life works when connected with

[415] Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, 46.

[416] Colebrook, *Gilles Deleuze*, 56.

[417] May, *Gilles Deleuze: An Introduction*.

[418] Colebrook, *Gilles Deleuze*, 56.

[419] May, *Gilles Deleuze: An Introduction*.

[420] Deleuze and Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*, 45.

some other machines: life is a production of machinic connections.[421] The connections between eye and light, brain and concept or mouth and language are all defined through machinic connections.[422]

Deleuze's concept of the cinema also reveals his thought of life as machinic connections, where the cinema illustrates the transformation of human thought and life through machines.[423] According to Deleuze, the cinema is already a "machinic" becoming, since it is composed of a series of images freed from the human eye.[424] The human eye as a machine connects with the eye of the camera, which is another machine and creates perceptions. These perceptions are beyond the human, defined through the connection of the human with the inhuman, a connection of two machines, which are also connected to other machines.

Deleuze and Guattari's machinic concepts can be plugged into the research on responsive environments. In the continuously mutating concept of body and embodiment in human machine interaction, responsive environments introduce Deleuze and Guattari's philosophical concepts such as becomings, flows, rhizomatic connections, and multiplicities. These concepts inherit the definition of the body (human and non-human) and the responsive mechanism as continuously transforming non-fixed machines which define new connections in their couplings and produce productions. In order to reveal how these machinic approaches alter the definition of the body and the concept of the machine, the following section traces Deleuze and Guattari's concept of desiring machines and that of the BwO.

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[421] Ibid, 27.

[422] Ibid, 41.

[423] Colebrook, *Gilles Deleuze*, 53.

[424] Ibid.

4.1.2 Desiring Machines and the BwO

Deleuze and Guattari define the body as a desiring machine where "the object of desire is another machine connected to it".[425] They describe desire as a production rather than a lack to be fulfilled and state that:

> "Desire does not lack anything; it does not lack its object. It is, rather, the subject that is missing in desire, or desire that lacks a fixed subject; there is no fixed subject unless there is repression. Desire and its object are one and the same thing: the machine, as a machine of a machine. Desire is a machine, and the object of desire is another machine connected to it."[426]

They define desiring machines as binary machines, where one machine is always coupled with another one to produce flows: "Everywhere *it* is machines - real ones, not figurative ones: machines driving other machines, machines being driven by other machines, with all the necessary."[427] In this sense, desire is regarded as a force initiating connections and constructing couplings of desperate machines, which come together and produce the flow in-between. Desiring machines interrupt the flow in order to produce another and condition the continuity, where the next one will interrupt to produce another flow for the subsequent.[428] Hence, desiring machines both initiate and break the flow of desiring production and become the "production of production."[429] In this concept, desire is perceived as a positive force that proposes a machinic relation rather than a mechanical one between the parts or machines.

[425] Deleuze and Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*, 36.

[426] Ibid.

[427] Ibid, 1-5.

[428] Ibid, 36.

[429] Ibid, 4.

Deleuze and Guattari provide several examples of production through the coupling of organ-machines and energy-machines. One of them is the breast-machine that is coupled with the mouth-machine and creates a new flow through interruptions.[430] In other words, in order to create a new flow, the current flow must be disrupted. Deleuze and Guattari refer to this process as 'grafting' and state that:

> "The coupling that takes place within the partial object-flow connective synthesis also has another form: product/producing. Producing is always something "grafted onto" the product; and for that reason desiring-production is production of production, just, as every machine is a machine connected to another machine."[431]

Deleuze and Guattari define the relationship between the bodies and the environment/world through a machinic approach, where each body is connected to another body to produce desire. The body is therefore considered as functioning like a desiring-machine, which continuously makes new connections and couplings with other desiring machines and produces a desire for production: a production of production.[432]

> "Hence everything is production: *production of productions,* of actions and of passions; *production of recording processes,* of distributions and of co-ordinates that serve as points of reference; *productions of consumptions,* of sensual pleasures, of anxieties, and of pain. Everything is production, since the recording processes are immediately consumed, immediately consummated, and these consumptions directly reproduced."[433]

[430] Ibid, 5.

[431] Ibid, 6.

[432] Ibid.

[433] Ibid, 4.

In the provided example, two desiring-machines (breast-machine and mouth-machine) are connected to produce a flow. Constituted by the connection of two desiring-machines, each flow necessitates an interruption for its existence. The breast-machine and the mouth-machine disconnect from another desiring-machine to create a flow. When they are connected, the breast-machine interrupts the flow of the mouth-machine and the mouth-machine interrupts the current flow of the breast-machine. The desiring-machines are connected through a series of flows, which are defined by interruptions in the flow: a system of interruptions.[434] These interruptions are regarded as initiating new flows and connections. Therefore, Deleuze and Guattari define a production in relation to machines, flows and interruptions:

> "Every machine functions as a break in the flow in relation to the machine to which it is connected, but at the same time is also a flow itself, or the production of a flow, in relation to the machine connected to it. This is the law of the production of production. That is why, at the limit point of all the transverse or transfinite connections, the partial object and the continuous flux, the interruption and the connection, fuse into one: everywhere there are breaks-flows out of which desire wells up, thereby constituting its productivity and continually grafting the process of production onto the product."[435]

Deleuze and Guattari define the body as a multiplicity of connected desiring-machines. It is not a single and fixed body that produces milk and connected to another single and fixed body desiring milk from it. But even though the body is considered as a multiplicity of desiring-machines, it is not defined as the sum of its constituting parts.[436] It is considered as if it cannot be broken down into

[434] Ibid, 38.

[435] Ibid, 36-37.

[436] Ibid, 38.

Gilles Deleuze and Félix Guattari also define the body composed of parts but not having a hierarchic structure and refer to the discussion of "rhizome" they used to describe theory and parts, which are distinct from each other.[437] The Deleuzo-Guattarian subject is not a fixed and single identity, but rather a multiplicity of machines that connect and disconnect to flows multiplicities and "wander about over the body without organs, but always remaining peripheral to the desiring-machines."[438]

In the continuous production of desire, the bodies (desiring-machines) pretend to become a body without organs (BwO), where flows flow into each other.[439] Since the flows are constantly interrupted to define new connections and flows, the BwO cannot be achieved and a continuous negotiation between the desiring production and the BwO is defined. The body is defined through this negotiation between desiring machines and the BwO, where the desiring machines try to interfere in the BwO, and the BwO resists them.[440]

Despite their common ground of desire, desiring-machines and the BwO depart from each other, since desiring machines define the body through organs and their coupling to form an organism (breast-machine connected to mouth-machine) but the BwO resist the need for organs and organisms.[441]This is the conflicting situation between desiring machines and the BwO. This resistance is associated with the conflicting situation with desiring machines; where

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research that allows for multiple, non-hierarchical entry and exit points in data representation and interpretation in A Thousand Plateaus.

[437] Ibid.

[438] Ibid, 17.

[439] Ibid, 38.

The term body without organs is borrowed from Antonin Artaud's radio play "To Have Done with the Judgment of God," where the following quote is provided; "When you will have made him a body without organs, then you will have delivered him from all his automatic reactions and restored him to his true freedom." (Artaud, Antonin. "To Have Done with the Judgment of God" *Antonin Artaud Selected Writings*. Ed. Susan Sontag. Berkeley, CA: University of California Press, 1976.)

[440] Ibid, 9.

[441] Ibid, 8-9.

desiring machines define a continuous process of production, the BwO inherits anti-production. It is an ongoing negotiation of desiring machines and bodies without organs; productive and non-productive, reterritorializations (desiring-machines) and deterritorializations (BwO).[442]

Deleuze and Guattari underline the importance of the machine in this negotiation, where the production of desiring machines and the non production of the BwO oppose each other. It is at this point that the machine is asserted to construct the relationship between the desiring-machines and the body without organs, between production and interception where they relate the continuity of production with the interruption of flow.[443] The reflections of the concept of the BwO together with the machinism concept can also be traced in several attempts at defining a responsive environment, where the entire design process is organized to attain the continuous flow of production. With an intention to define the continuity of production, responsive environments enable the conception of bodies as desiring-machines.

Through the coupling of desiring-machines such as human, non-human or machine bodies and the environment, which can also be considered as a body, responsive environments define productions through machines, flows and interruptions. It is at this point that the machine is asserted to construct the relationship between the desiring-machines and the body without organs, between production and interception where they relate the continuity of production with the interruption of flow.[444] Deleuze and Guattari refer to Carrouges's definition of the celibate machine to form a new association

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[442] Ibid, 33-34.

[443] Ibid, 17-18.

[444] Ibid.

between desiring machines and the BwO, where it is anticipated that through this new alliance the machine can manifest something new and different.[445]

4.1.3 Bachelor Machines

Bachelor machines form another concept of machine that mark the distinctions of a machine form a mechanism as well as the machinic from the mechanic. The term "bachelor machine" *(machine célibataire)* is used by Marcel Duchamp in describing his work called *"The Bride Stripped Bare by Her Bachelors, Even" (also known as the Large Glass).*[446]

Large Glass is a complex work of art produced during 1915-1923 by Duchamp that led the discussion of bachelor machines. Composed of two glass panels made up of different materials, this complex work is separated in two domains: the upper is the bride's domain and the lower is the bachelor's domain.[447] Though these two domains seem to be completely separated from each other, the controversial relation between these two domains relates them to each other.[448] Both parts are composed of several geometric configurations melding together to create the larger composition. In the upper domain of the composition the bride is depicted with several geometric forms. In the lower domain, the bachelors are depicted with an assemblage of pistons, water mills and chocolate grinder, which are driven by the desire to transcend to the bride's domain that is forever beyond their reach.[449] The bachelor apparatuses in the

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[445] Ibid.

[446] Schwarz, Arturo. *The Complete Works of Marcel Duchamp* (Delano Greenidge Editions, 1997).

[447] Joseph, Branden Wayne. Random Order: Robert Rauschenberg and the Neo-Avant-Garde (Cambridge, Mass.: MIT Press. 2003).

[448] Ibid.

[449] Henderson, Linda Dalrymple. "Etherial Bride and Mechanical Bachelors: Science and Allegory in Marcel Duchamp's "Large Glass." *Configurations*. Vol. 4 No. 1 (Winter 1996): 91-120.

lower domain are driven continually with an unfulfilled desire that they can never reach.[450] This somehow deceptive relation between the domains creates ambiguity and proposes a blurred experience. Duchamp describes this lower domain as a bachelor machine in his notes.[451]

One of the most remarkable explanations of the bachelor machine is by Michel Carrouges in *Le macchine Celibi/The Bachelor Machines*, where he referred to Duchamp's notes on the *Large Glass* (figure 21). Considering Duchamp's work, Carrouges defines the bachelor machine as *a closed, self-sufficient system* of which common themes include frictionless, sometimes perpetual motion, an ideal time and the magical possibility of its reversal, the dream of the mechanical reproduction of art, and artificial birth and reanimation.[452] Continuing his description, Carrouges states that:

> "The Bachelor Machine can consist of only one peculiar, strange and unknown machine, or of an apparently useless arrangement of parts. It can unify a lightning rod, a clock, a bicycle, a train, a dynamo, and even a cat or any part of an object or its remains. It is of no importance. The Bachelor Machine is not connected with any purpose, like a machine that is subject to the physical laws of mechanics or the social demands of usefulness. The Bachelor Machine is a simulacrum, one encounter in a dream."[453]

Henderson describes the bride as "a projection of the fourth dimension in the form of a three dimensional geometrical section, which in turn has been reduced to the two dimensions of the glass," whereas the bachelors depicted in the lower domain cannot reach the bride despite their motivation and desire to transcend to the upper domain (bride's domain). Henderson states that the bachelors can never reach the bride because "the world they inhabit is three-dimensional world, whereas the bride inhabits an impenetrable four-dimensional world."

[450] Henderson, Linda Dalrymple. *Duchamp in Context: Science and Technology in the Large Glass and Related Works* (Princeton University Press. 1998).

[451] Joseph, Random Order: Robert Rauschenberg and the Neo-Avant-Garde.

[452] Carrouges, Michel. "Directions for Use." *Le Macchine Celebi/The Bachelor Machines* (New York: Rizzoli, 1975).

[453] Ibid.

In this sense, the bachelor machines depart from mechanisms, where the effectiveness and efficiency of the system loose their importance and are replaced with an intentional search for mechanical failure.[454] However, it is through this failure of mechanical production that the bachelor machine introduces another realm of productivity accompanied by the complexity of the machine and the intricate relations. It hides the laws and working principles or creates confusion about them while representing more than the visible as a consequence of this confusion. It can therefore go beyond being a mechanism and produce new and complex relations, desires and depictions.

Deleuze and Guattari consider the bachelor machine for defining the association between the BwO and desiring machines. The bachelor machine defines the folding of these two opposing concepts over each other. As discussed in the previous section, a desiring-machine describes its production through interrupting the continuous flows in order to produce another, where the content of the first flow (product) is regarded as the expressive medium of the second (producer).[455] As opposed to desiring-machines, the BwO does not produce anything, rather reproduces chains of flows that pass through one another.

Duchamp's bachelor machines are connected to the BwO and plugged into the desiring-machines and construct the relationship between them.[456] This constructed relationship is similar to the relationship between the bachelor's

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[454] Ibid.

The failure concept is used in reference to Carrouge. Carrouge state that: "resolutely opposed to the restricted industrial regulations of utility, energy efficiency, and exchange, the bachelor machine is a device that operates only by breaking down; it manifests itself most explicitily in its propensity for a form of mechanical failure that is at the same time a spectacular self consumption."

[455] Krauss, Rosalind. "Bachelors." *October*. Vol. 52 (Spring, 1990): 52-59.

[456] Ibid.

world of production and the bride's domain of inscription.[457] As the bachelor machine achieves the folding of one domain over the other, it can also introduce the association between two opposing concepts nourished from each other. Therefore, the bachelor machine of Deleuze and Guattari’s Anti-Oedipus constructs the relation between the desiring-machines and the BwO.

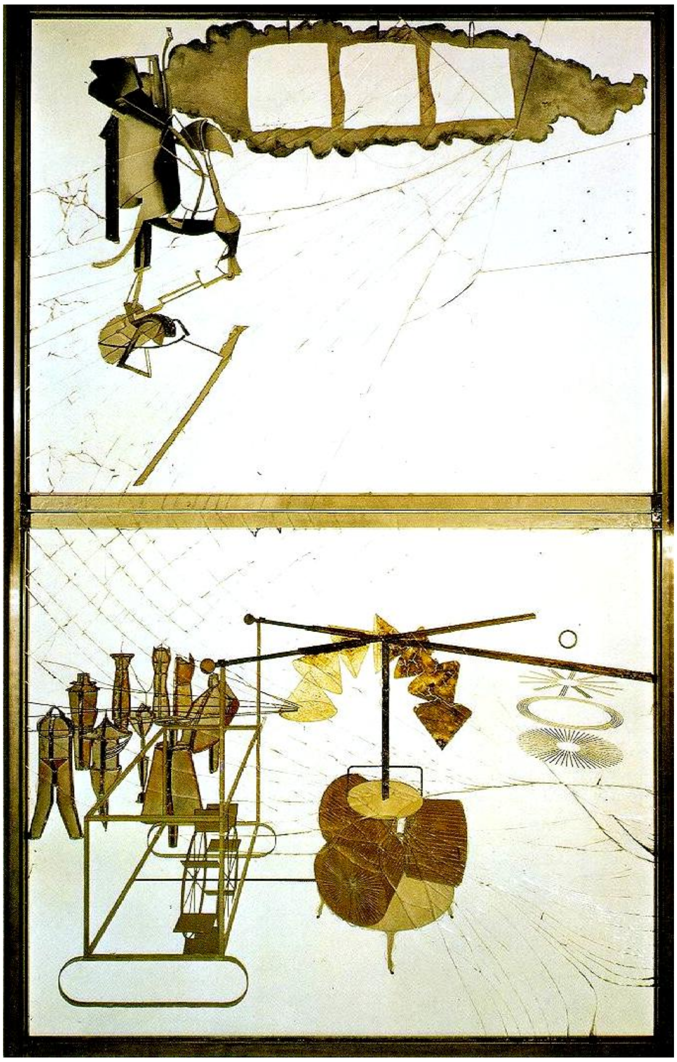

Figure 21: “The Bride Stripped Bare by Her Bachelors, Even (Large Glass)” by Marcel Duchamp.1915-1923.

Source: Henderson, Linda Dalrymple. *Duchamp in Context: Science and Technology in the Large Glass and Related Works*. Princeton University Press. 1998.

[457] Ibid.

4.1.4 R&Sie(n) and Schizoid Machines

R&Sie(n) introduce a different concept of the machine through reference to Duchamp's bachelor machine, as well as Deleuze and Guattari's desiring-machine.[458] Roche defines the machine not as producing simple efficiency but as an operating system that introduces unpredictability and indeterminism.[459] According to Roche, machines have always been pretending to do more than what they were programmed to do and alternate phantasms, frustrations and fears inspired by their own ability to break free and threaten us.[460] Considering machines less as operational devices providing the accuracy of the production, but as vectors of narration, Roche declares how they relate the use of the machine in their design strategy; practice as fiction, fiction as practice, speculation, and research where reality becomes a narrative strategy.[461] Along with this correlation, Roche also defines the blurriness experienced as a consequence of the machinic practice as a potential intentionally sought for during the design process and states that:

> "The blurriness created between what they (machines) are supposed to do, as perfect alienated and domesticated

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[458] Within the content of this research an interview was conducted with François Roche in January 2010, in Paris. The intellectual inspiration provided by François Roche during this interview and also the theoretical and technical information he provided about his recent works such as "I've Heard About", Olzweg and "An architecture des humeurs" was invaluable. The generous discussion he provided during the interview allowed to look beyond the technical aspects and discuss the concept of responsiveness with its philosophical references and to envisage the processes and protocols proposed by R&Sie(n). The scope of this study has shifted significantly after this interview and the research process has been reformulated after the questions raised concerning the exploration of the links between the human body and the environment in reference to the experiments carried by R&Sie(n).

[459] Roche, François. "Alchimis(t/r/ick)-machines." http://www.new-territories.com/roche%20text.htm. [Accessed: March, 2011].

[460] Roche, François. "(Science) Fiction, Ecosophical Apparatuses and Skizoid Machines: Animisim, Vitalism and Machinisim as a Way to rearticulate the need to Confront the Unknown in a Contradictory Manner." *AD: Ecoredux.* Vol. 80 No. 6 (November-December 2010): 64-71.

[461] Ibid.

> creatures, and the anthropomorphic psychology we intentionally project on them, creates a spectrum of potentiality, both interpretative and productive, which is able to re-'scenarise' the operating processes of the architectural field. These multiple disorders, this kind of schizophrenia, could be considered a tool for reopening processes and subjectivities, for re-'protocolising' indeterminacy and uncertainties."[462]

Roche defines these machines as schizoid machines that pretend to do something while doing something else. This inconsistency leads to a confusion about the functionality of the machine and hence participates in creating blurriness.[463] In this sense, Roche sets the relationship between schizoid machines and bachelor machines, where the machine does not depend on its efficiency of production and departs from cybernetic machines. As a consequence of the blurriness and the unpredictability of the schizoid machine, the human's relationship to reality alters. This condition also differentiates the schizoid machine from the cybernetic machine, which is after the efficiency of production and in a strong reliance on reality. In their works, R&Sie intentionally introduce an unpredictable behavior to the machine in order to create the confusion of what they pretend to do and are actually doing. Through this approach, they enable the definition of schizoid machines and alter the human's relationship to reality.[464] This altered experience is asserted to lead to paranoia and a parallel reality that is perceived and described through fiction.[465] Roche states that:

[462] Ibid.

[463] Dialogue between François Roche and Anna Neimark. http://arch.usc.edu/content/pages/cm/uploadedmedia/idnws_fall_091268772390613.pdf. [Accessed: April, 2011].

[464] Roche, François. "An architecture "des humeurs." http://www.new-territories.com/blog/architecturedeshumeurs/?p=14[Accessed: January, 2011].

[465] Dialogue between François Roche and Anna Neimark. http://arch.usc.edu/content/pages/cm/uploadedmedia/idnws_fall_091268772390613.pdf. [Accessed: April, 2011].

> "All paranoia produces a parallel reality in your mind, filtering perception, you can perceive it and describe it through fiction. Lewis Carroll's Alice in Wonderland operates on an immediate level when he introduces illogic through pure logic, what in French one would call *le malentendu*. *Malentendu* – the wrongly heard or misunderstood – is a tool of linguistic exchange; it is a kind of stutter. We need misunderstanding or stuttering in order to communicate."[466]

The proposed blurriness through the application of these operative, fictional and speculative scenarios as a new strategy proposes blurriness and enables to alter architectural practices and rearticulates the relation of a situation with an environment[467] Consequently these approaches "transform the perception of the spaces we inhabit and psychologically inhabit us"[468] and introduce new relations and experiences.

4.2 Machinic Approaches in Responsive Environments

In the preceding sections, the concept of the machine has been discussed from different viewpoints and how these views oppose the association of the machines with mechanisms and its techniques as well as with the extension, replacement or improvement of the body for the efficiency of production has been provided. This section presents the practice of machinic approaches in the definition of responsive environments and the transformation of mechanisms to machines through references to contemporary examples of responsive environments. The common aspect of the projects presented in this section is that they all avoid the definition of machine as an agent of production and efficiency, but rather conceive it as a strategy that participates in the process and produces new connections, flows, interruptions.

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[466] Ibid.

[467] Ibid.

[468] Ibid.

In machinic approaches, the hierarchic orders between the participants of the process are dissolved and all participants are considered as bodies affecting each other and being affected from each other during their interactions. The responsive environment maintains its presence as a dynamic evolving environment through the interaction of the bodies, where this interaction produces flows of information, desires, demands etc., where bodies evolve and transform during the interaction and present a non-stable non-fixed attitude. Assessed in the light of Deleuze's concepts of body and machine, these transforming bodies of responsive environments, either human or non-human, can also be considered as machines that produce machinic connections. This can be considered as a significant change in the conception of responsive environments and can be regarded as a change in the concept of responsiveness and human-machine interaction in responsive environments.

In this transformed interaction process, the machine can go beyond its limits, discover more than its expected outcomes, and define new flows of information, new relations between parties or experiences. The apparatuses used by these machines, either as a medium or as an instrument, enable to enhance the participatory potential of the machines instead of their instrumental use. According to François Roche, these machines and apparatuses "can articulate different arrows of time and layers of knowledge."[469] Channeling its potential to the interaction process through their apparatuses, machines can operate information and define the input and output through rules and relations.[470] Through the rules and protocols defined, they can negotiate their potentials and define new artifacts, desires and relations, but more specifically they can infiltrate the relationship between body, mind and environment. These machines can affect and articulate the subjective or

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469 Roche, François. "Alchimis(t/r/ick)-machines." http://www.new-territories.com/roche %20text.htm. [Accessed: March, 2011].

470 Ibid.

objective productions of humans and their mutual relationships through the proposed processes, protocols and apparatuses.[471]

Taking into consideration these redefinitions, this section analyzes four different attempts at defining a responsive environment; *Olzweg* and *An architecture "des humeurs"* projects by R&Sie(n), *SYS*017.ReR*06/PiG-EqN\ 5*8* project by Mathieu Briand and the *Hormonorium* project by Jean-Gilles Decosterd and Philippe Rahm. These four projects define all parties involved in the interaction as bodies actively participating in the definition of the environment and affecting each other as well as affected from each other during the interaction process. They also consider machine participants outside of their mechanist connotations and refer to desiring machines, bachelor machines or schizoid machines in their opposition to the mechanistic approaches used in responsive environments. In these works, the machines are neither considered as pure mechanisms alienated from human like attributes, nor designed to mimic and simulate these attributes. Rather, they are supposed to be both interpretative and productive.

4.2.1 Olzweg

Olzweg is an unrealized project designed by R&Sie(n) in 2006 for the courtyard of the Regional Contemporary Art Collection (FRAC_ Fonds Regional d'Art Contemporain) that is based at Orléans in France.[472] A maze is proposed for the courtyard that is made up of recycled glass bars to form an open-air space of exhibition, interaction, circulation etc .[473] It is proposed that the entire structure be constructed out of glass elements. The glass structure

[471] Ibid.

[472] R&Sie(n). Olzweg. http://www.new-territories.com/welostit.htm. [Accessed: January, 2011].

[473] Ibid.

inherits a labyrinth walkway and access points in its thickness, which are defined according to a script and carried out by large machines of robotic arms (figure 22-23).[474]

The entire structure is to be constructed continuously in a period of more than 10 years by these machines according to the script, which allows reprogramming of the construction of the labyrinth and the structure during the process. François Roche states that their proposal is a work that is 'going to be done,' which is an unachieved process of construction;

> "Our heterotopic proposal was to dream up a "body without organ,'' a *CsO (corps sans organe)* in the sense of Antonin Artaud and Deleuze, a kind of a desiring machine, a machine that articulates substances and intensities, slipping over surfaces, infiltrating flesh and infiltrated by flesh, in a multitude of possibilities. This BwO (body without organ) is generated by smearing the existing building, as if with glue, sliming it to rediscover, in the massive depth of its viscosity, a way to embed a multitude of accesses, of walkways, and forked paths, of unlimited relationships and geographical detours and twists."[475]

This continuous redefinition makes visitors to lose their references and coordinates in the unachieved, unfinished labyrinth.[476] In order to position themselves within the labyrinth, the visitors use a personal digital assistant (PDA) on radio frequency identification (RFID) devices. [477] The labyrinth continuously evolves during the construction process and the visitors try to define new paths by moving inside it through using these devices.[478] In these

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[474] Ibid.

[475] Ibid.

[476] Roche, François. "Bodies without Organs-BwO." *AD: Neoplasmatic Design.* Vol. 78 No. 6 (November-December 2008): 68-69.

[477] Ibid.

[478] Ibid.

continuous transformations, both the human and the machine participate in the redefinition and reconstruction of the labyrinth.

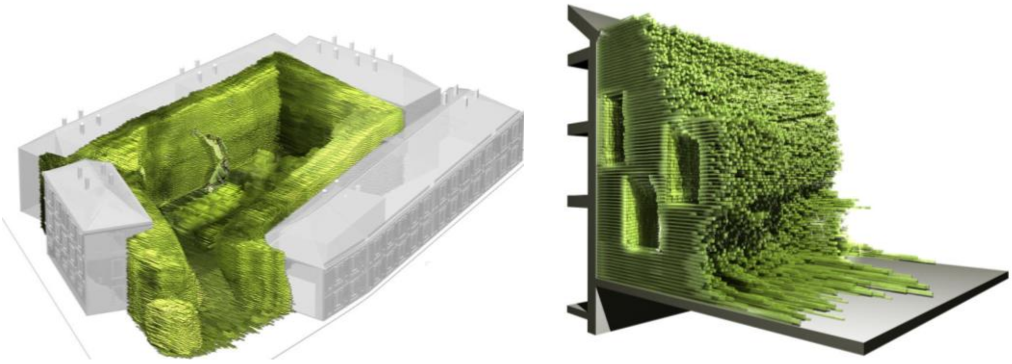

Figure 22: Labyrinth of paths embedded within the glass components in Olzweg.

Source: Corbellini, Giovanni. Bioreboot: The Architecture of R&Sie(n). New York: Princeton Architectural Press, 2009.

Through this process, the machine creates uncertainty and un-determinism, while constructing the constantly mutating building. These continuous rearrangements can be considered as leading to randomization and uncertainty about the final form and structure of the construction.[479] The randomness in construction and the ambiguity in the process and form introduced by these machines propose a blurred experience. The blurriness is attained through machines that pretend to do more than they are supposed to do while producing new conditions and connections. In *Olzweg*, the machines are not considered as techno-cybernetic apparatuses but instead as agents of indeterminism that participate in the narration of the project; they are considered as bachelor machines:[480] François Roche defines this machine as a bachelor machine; "a 12-meter-high robot, wearing glass clothes, a glass suit, able to fully disappear,

[479] R&Sie(n). Olzweg. http://www.new-territories.com/welostit.htm. [Accessed: January, 2011].

[480] Ibid.

for hiding itself, and be wrapped by the substances it aggregates…it is a vector of parametric design, uncertainty, randomness and incompletion."[481]

The main motivation of the machine in this project is not the mechanical precision and the efficiency of the production, but rather the complexity of the production attained by the ambiguity and the intricacy of the process. Continuous reprogramming and reconstruction of the structure can be considered as a mechanical failure, which is intentionally sought to attain the desired ambiguity. The working principles of the machine are not noticeable to the visitor and s/he is intentionally confused during the construction process. Therefore, it is possible to assert that in this project, the machine is not defined as a cybernetic machine, but instead as an agent of indeterminism, which is responsive to the mutating desires during the construction process and participates in the narration of the project "in its real, machinist and fictional inscription."[482]

Figure 23: Virtual model of the robotic arm in Olzweg.

Source: Corbellini, Giovanni. Bioreboot: The Architecture of R&Sie (n). New York: Princeton Architectural Press, 2009.

[481] Roche, François. "Alchimis(t/r/ick)-machines." http://www.new-territories.com/roche%20text.htm. [Accessed: March, 2011].
[482] R&Sie(n). Olzweg. http://www.new-territories.com/welostit.htm. [Accessed: January, 2011].

Definition of the responsiveness of the system through a machine instead of a mechanism enables to attain an indeterminate and unpredictable design and construction process. The protocols for interaction, mutation and construction are defined beforehand, where the definition of the final form is left to the process, which is an ongoing process of 10 years. The continuous construction and rearrangements by these machines enable randomization and uncertainty about the final form and structure of the construction.[483] During this process, the participant continuously perceives different arrangements mutating in time and altering his/her experience with and within the building. Therefore, *Olzweg* defines a re-adaptable and reprogrammable machine that depends on the mutation of the environment through the inputs.[484] This is made possible by embracing the machinism concept as a design strategy and the search for attaining the responsiveness of the process through the machine which is not used only to initiate efficiency but also different relationships, realities and experiences.

4.2.2 An Architecture "des humeurs"

Another project where it is possible to uncover the machinism discussion is the recent research project and exhibition by R&Sie(n) titled as *An architecture "des humeurs"*, exhibited at *Le Laboratoire*, Paris, in 2010. Aiming to develop a computational approach to reread human corporealities in reference to the biological and physiological data obtained from the visitors, the research project physically constructs contradictions (figure 24-45).[485] In order to realize this research, different fields of exploration such as neurobiology, mechanization and mathematical protocols are brought together to assemble

[483] Ibid.

[484] Roche, François. "Alchimis(t/r/ick)-machines." http://www.new-territories.com/roche%20text.htm. [Accessed: March, 2011].

[485] Zwingenberger, Jeanette. "Molecular Interfaces." *Movement*. No. 54 (2010).

the structural, transactional and relational operating modes.[486] The potential offered by computational design tools and strategies are also utilized in this project to detect the body chemistry and gather data about the participants' adaptation, sympathy and empathy, when confronted with a particular situation and environment.

The research project considers the exhibition area as a data collection arena, where it is tried to discover the invisible parts of the body through the visitors' interaction with a machine on entering the exhibition area. Upon entrance into this area, the visitor is invited to take a seat and face the screen of the receptive machine that traces information from the visitor. A person accompanying the visitor asks to place his/her hand in the receptacle that assesses the balance of the body and says that:

> "Please place your hand in this receptacle… Over the next 30 seconds it will assess the balance of your body. Your body will thus become the vector of your emotions. During the test a harmless vapor will be released to help us record any evolution in your emotional state. Please allow this vapor to flow through your body. Breathe in deeply. This vapor is in no way harmful… I will absorb the same substance simultaneously. Facing you is a constructive machine, a robot. It will act as both your guide and at the same time an indicator of the state of your emotions. It is a dynamic portrait of you… Its movements are directly affected and influenced by the nanoparticles that you will be inhaling and exhaling. Please breathe deeply and slowly… lose yourself in the labyrinth, the twists and turns, the ramifications, the arborescence…" This protocol is an extract from a scenario concerning the collection of physiological data through the use of nanotechnology. [487]

[486] "Protocols & Process." Dialogue between Francois Roche & Caroline Naphegyi. http://www.new-territories.com/blog/architecturedeshumeurs/?p=14. [Accessed: January, 2011].

[487] Zwingenberger, "Molecular Interfaces."

The movie that exposes the dialogue between the visitor and the accompanying person can be found at R&Sie(n) website:
http://www.new-territories.com/blog/architecturedeshumeurs/?page_id=914

In this interaction the body acts as a vector of emotions, where these emotions are captured and recorded through the vapor released to flow through the body of the visitor. The emitted vapor helps to detect emotions at the molecular level and the screen of the receptor maps the four moods of the visitor: Dopamine (the pleasure molecule), Adrenalin (the molecule of the ability to react to a need for energy), Serotonin (the molecule of melancholy or "depression"), Cortisol (the molecule of anxiety or stress).[488] In this interaction, the receptacle is defined as a constructive machine that indicates the state of the emotion of the visitor. [489]

Figure 24: R&Sie(n), An Architecture "des humeurs", Le Laboratoire, Paris, France, 2010.

Source: Roche, François. " An Architecture des humeurs." http://www.new-territories.com/blog/architecturedeshumeurs/?p=14 [Accessed: January, 2011].

Data provided through scanning the expressions of desires, conflicts or contradictions uncovers the emotional transactions of the body, according to which habitable morphologies for his/her future dwellings are proposed.[490]

[488] Ibid.

[489] "Protocols & Process." Dialogue between Francois Roche & Caroline Naphegyi. http://www.new-territories.com/blog/architecturedeshumeurs/?p=14. [Accessed: January, 2011].

[490] Roche, François. "An architecture "des humeurs." http://www.new-territories.com/blog/architecturedeshumeurs/?p=14 [Accessed: January, 2011].

These morphologies are informed by computational, mathematical and machinist procedures, where the emotional transactions of the body are considered as inputs and trigger the uncertain and indeterminate protocols.[491] This attempt at integrating contradictions in the expressions of desires is expressed by the architects as:

> "We decided to take the preliminary step of revisiting the contradictions within the very expression of these desires, both those that traverse public space because of their ability to express a choice, a desire conveyed by language, on the surface of things, and those preexisting and perhaps more disturbing but equally valid desires that reflect the body as a desiring machine (as Deleuze put it), with its own chemistry, imperceptibly anterior to the consciousness those substances generate."[492]

The visitor experiences architectural models in other rooms of the exhibition . These models are prototyped according to the data obtained from the visitor. The data provided is processed with a script, of which mathematical algorithm acknowledges the growth of spaces and their evolution according to the contradictions and contingencies of the human body.[493] In this project, responsiveness is satisfied through reacting to the inputs such as contingencies, conflicts, and desires, which are scanned from the human and provide an output for this blurred situation through making use of computational tools and strategies of design, where a computer script interacts with the human psyche.

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[491] "Protocols & Process." Dialogue between Francois Roche & Caroline Naphegyi. http://www.new-territories.com/blog/architecturedeshumeurs/?p=14. [Accessed: January, 2011].

[492] Ibid.

[493] Zwingenberger, "Molecular Interfaces."

The growth pattern of these structures as asserted to resemble "coral structures that do not simply evolve upwards but which proliferate in every direction like a relief map: In this way branches and subdivisions are able to reunite even after their division."

In *An architecture "des humeurs"*, machines are used as vectors of production, where they create the morphology of the habitat according to a mathematical protocol.[494] This mathematical protocol is formulated according to "set theory" that enables to reflect the desires of the human. Through this way, it becomes possible to be receptive to the desires and contradictions traced verbally and chemically. The mathematical model and the algorithm proposed can react to these contradictions since they also inherited "may be" and "perhaps" conditions besides "if", "else" conditions. Therefore, it is possible to define "an urban structure based on these computational and robotic procedures," where the vectors of variability and indetermination make visible the potential of heterogeneous aggregations.[495] The morphology provided as a result of uncertain and indeterminate protocols can be considered as a negotiation of conflicts and desires of the human being, which is reflected through computational, mathematical and machinist procedures. Through these procedures, the morphology stimulates the unexpected and uncertain expressions of the relations between the environment and the participant. Roche defines their machinic approach as follows:

> "A utopian machine to produce a self-organized urbanism conditioned by a bottom-up system in which the multitudes (in Spinoza and Antonio Negri's use of the word) are able to drive the entropy of their own system of construction, their own system of *vivre ensemble*. This *architecture des humeurs* is based on the potential offered by contemporary science to reread human corporalities in terms of their physiology and chemical balance. It uses technology to make palpable and perceptible the emotional transactions of the "animal body," the headless body, the body's chemistry, so that it informs us about individuals' adaptation, their sympathy and empathy, when confronted with a particular situation and environment,

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494 Corbellini, Giovanni. Bioreboot: The Architecture of R&Sie(n) (New York: Princeton Architectural Press, 2009).

495 "Protocols & Process." Dialogue between Francois Roche & Caroline Naphegyi. http://www.new-territories.com/blog/architecturedeshumeurs/?p=14. [Accessed: January, 2011].

and adapts this result to an endless process of construction through "*machinism"* behavior."[496]

Figure 25: R&Sie(n), Architecture of Humors, Le Laboratoire, Paris, France, 2010.

Source: Roche, François. "An Architecture des humeurs." http://www.new-territories.com/blog/architecturedeshumeurs/?p=14 [Accessed: January, 2011].

In the *An architecture "des humeurs"*, machinism is embraced as a design principle and machines are not defined as cybernetic machines or mechanisms. Machines are defined as producers of antinomies and absorbers of human subjectivities.[497] This project provides a rereading of desires, contradictions and emotions of the body by a receptive machine that traces the stimuli provided by the body, which are dopamine, hydrocortisone, melatonin, adrenaline and some molecules secreted by the body itself and converts them into constructive impulses.[498] This constructive and narrative machine hence responds to the desires and conflicts of the body.[499] This approach considers the body as a desiring machine that produces flows of desires, emotions and

[496] Roche, François. "Alchimis(t/r/ick)-machines." http://www.new-territories.com/roche%20text.htm. [Accessed: March, 2011].

[497] Ibid.

[498] Zwingenberger, "Molecular Interfaces."

[499] R&Sie(n). "An Architecture of Humors," Tresholds. Cambridge: MIT Press. No:38 (2010): 14-26.

conflicts when connected with the receptive machine. This coupling is similar to the “breast-mouth” coupling discussed in the definition of desiring machines by Deleuze and Guattari.

This project can also be considered as defining a schizoid machine, where the assembly of machines act as a whole body that produces flows of information and pretend to the something while doing something else; they pretend to map the states of the emotions while processing the information through running the mathematical models and the script at another level. The user connecting with the receptive machine and breathing the released vapor confronts with a coral like structure when s/he crosses to another room. The structure is the proposed habitat for his/her desires, emotions and conflicts, of which principles cannot be fully grasped by the visitor. This situation creates a blurriness and unpredictability, while alters the human’s relationship to reality. It is a parallel reality that is created, which runs in accordance with the process. When the visitor is interacting with the receptive machine, the script is left to run at the background and the habitable morphology that reflects the information transmitted by the visitor’s body is constructed. The intention to alter the relationship with reality departs this machine from cybernetic machines, which strongly depend on reality and express it with apparent laws and principles. How machinic approaches used in responsive environments can alter the relationship with reality will be discussed in the following sections.

4.2.3 Hormonorium

Another project that defines an architectural space in relation to the body and establishes continuity between the human and the non-human is the *Hormonorium* project, which was exhibited as the Swiss Pavilion at the 8th Biennale of Architecture in Venice in 2002.[500] Designed by the team Jean-

[500] Rendell, Jane. *Art and Architecture: A Place Between* (London; New York : I.B. Tauris. 2006).

Gilles Decosterd and Philippe Rahm, the *Hormonorium* is proposed as a public space that dissolves the physical boundaries between space and organism. Defining the project as a physiologically stimulating space, Rahm states that;

> "The Hormonorium is an "im-mediate" space, no longer resorting to semantic, cultural or plastic media for the making of architecture. By exerting an influence outside the realm of the senses and the skin, the Hormonorium creates a synthesis of the organic, of mood and space, by establishing a continuity between architecture and human metabolism, between space, light and the endocrine and neurological systems."[501]

Through triggering the physicochemical mechanisms of the visitor, this project aims to define a change in the understanding of space and the way the environment is inhabited. The assemblage of devices that act on the endocrine and the neuro-vegetative systems of the visitor, enable to represent a climate, close to that of high mountains, which is experienced by the visitor through respiration, the retina and the skin.[502] This representation is made possible with the manipulated levels of UV light that affect the hormonal level of the visitor. Hundreds of fluorescent tubes are placed under the plexiglass floor surface (figure 26).[503] These lamps emit a white light that reproduces the solar spectrum with UV light and illuminate the room so brightly that the boundaries of the room start to disappear for the visitor.[504]

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[501] Rahm, Philippe. http://www.philipperahm.com/data/projects/hormonorium/index.html. [Accessed: August, 2011].

[502] Ibid.

[503] Kiel, Moe. *Thermally Active Surfaces in Architecture* (New York: Princeton Architectural Press 2010).

[504] Rahm, Philippe. http://www.philipperahm.com/data/projects/hormonorium/index.html. [Accessed: August, 2011].

Figure 26: Hormonorium exhibited in the 8th Architecture Biennale of Venice in 2002.

Source: Rahm, Philippe. http://www.philipperahm.com/data/projects/hormonorium/index.html. [Accessed: August, 2011].

The radiation from the floor cannot be blocked by the eyelids or eyelashes as in the case of snow and stimulates the retina and the brain of the visitor.[505] As a consequence of this stimulation a sharp decrease in the melatonin level is experienced (figure 27).[506] The decrease in the level of this hormone allows the visitor to experience a decrease in fatigue, but a probable increase in physical capabilities.[507]

The decrease in the melatonin results in a significant change in he nitrogen level at the *Hormonorium* and reduces the oxygen level.[508] Being equal to the oxygen level at an altitude of 3000 meters, the oxygen deficiency causes slight hypoxia, which manifests itself by confusion, disorientation or bizarre behavior. [509] Being exposed to lower oxygen supply, the visitors' body

[505] Archinect. "Philippe Rahm." http://archinect.com/features/article/96362/philippe-rahm-part-1. [Accessed: August, 2011].

[506] Ibid.

[507] Rahm, Philippe. http://www.philipperahm.com/data/projects/hormonorium/index.html. [Accessed: August, 2011].

[508] Rahm, Philippe. http://www.philipperahm.com/data/projects/hormonorium/index.html. [Accessed: August, 2011].

[509] Archinect. "Philippe Rahm." http://archinect.com/features/article/96362/philippe-rahm-part-1. [Accessed: August, 2011].

produces more erythropoietin, which stimulates the production of red blood cells, thus increases the amount of oxygen supplied to the muscles. [510] Hence, the physical capabilities of the body are increased. Therefore, the room stimulates the physiology of its participants' body and transforms its physical performance through the amount of bright light released from the floor. This can be considered as defining a new experience of embodiment, where the environment and the visitor's experience of the environment fold over the body and their embodiment are reflected through the physical transformations of the body.

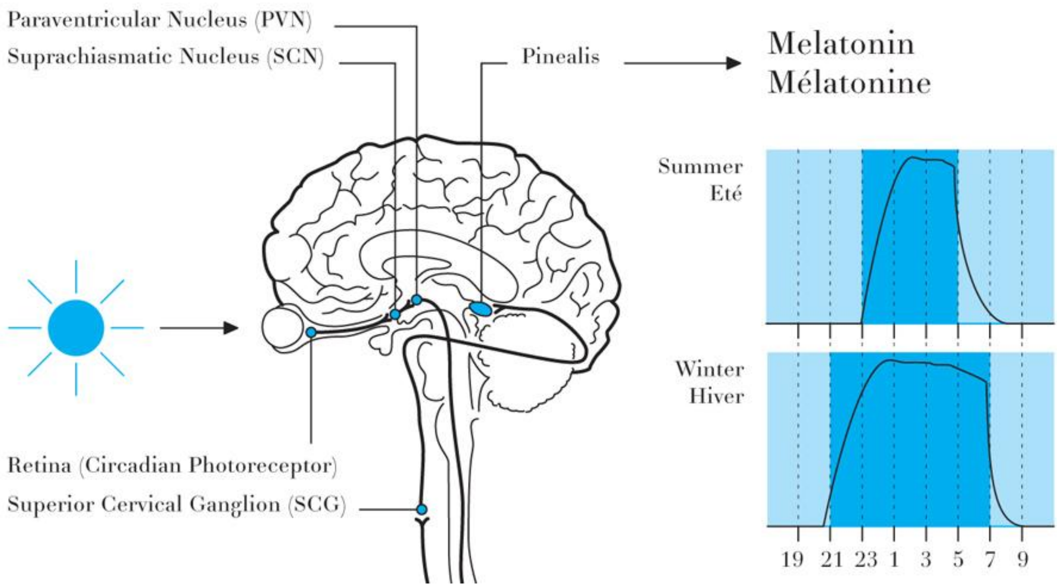

Figure 27: Diagrammatic expression of the Hormonorium exhibited in the 8th Architecture Biennale of Venice in 2002.

Source: Rahm, Philippe. http://www.philipperahm.com/data/projects/hormonorium/index.html. [Accessed: August, 2011].

Through the stimulation of physio-chemical mechanisms, this project engenders the transformation of the environment and also the bodies interacting with the environment. The continuity and the interaction between the environment and the visitors, the light source and the neurological systems,

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[510] Ibid.

enable to define a responsive environment,where the mechanisms are excluded from the interaction process. In this responsive environment, the visitor and the environment connect to each other and the visitor is altered physically during this connection. When the connection ends, the flow of triggering effects are interrupted and hence the physical alteration terminates gradually.

The body and the environment are recognized as machines that transform in relation to their connection with each other and hence are unstable. It is not suggested that bodies become literally machines; rather, their conception as machines enables the extension of their respective potentials and boundaries.[511] These machines can be considered as a manifestation of desiring-machines, where they couple with other machines to produce flows. In this project, the flows are created through their connection, where they affect and are affected from each other's conditions. The change in the amount of light provided by the environment changes the hormone levels of the visitor, which in turn affects the experience of the visitor in the environment and its impacts on the environment. With this conception, this project can be considered as an altered expereience of responsiveness that is defined through machinic approaches and engenders a modification in the understanding of responsive environments.

4.2.4 SYS*017.ReR*06/PiG-EqN\ 5*8

Another important example that introduces new definitions for embodiment and human-machine interaction in responsive environments is Mathieu Briand's proposal; "*SYS*017.ReR*06/PiG-EqN\5*8*". Briand is a French artist, who in most of his installations embraces a domain that includes electronic media, music, new technology, architecture, and virtual space, as well as games. Briand's project was exhibited at the MIT Visual Arts Centre as part of

[511] Massumu, Brian. "Realer than Real: The Simulacrum According to Deleuze and Guattari." http://www.opa-a2a.org/dissensus/wp-content/uploads/2008/04/massumi_brian_realer_than_real.pdf. [Accessed: August, 2011].

the "Sensorium: Embodied Experience, Technology, and Contemporary Art" exhibition in 2006 at the MIT List Visual Arts Center, curated by Bill Arning, Jane Farver, Yuko Hasegawa, Marjory Jacobson and Caroline A. Jones.[512]

The performance space is surrounded by nine sockets and three cameras, which are linked through a matrix made up of pre-determined combinations (figure 28).[513] The participants wear a head-mounted system, which is composed of a camera, a video-recorder and a monitor positioned in front of the eye.[514] The participants are also equipped with a connector that can be plugged into the sockets placed around the exhibition space.[515] These wearable apparatuses enable data transfer and also exchange of audiovisual experiences between the participants. [516] The participants can plug or unplug their apparatuses and switch to the perceived views of other participants.[517] When the participant plugs the connector into a socket, s/he can see the view provided either by the cameras installed into the building or worn by another participant. Therefore, by plugging the connector to different sockets, the participant can perceive different perspectives and be alienated from his/her visual perception.

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[512] Jones, Caroline A. *Sensorium: Embodied Experience, Technology, and Contemporary Art* (Cambridge, Mass.: MIT Press : The MIT List Visual Arts Center, 2006).

[513] Ibid.

[514] Briand, Mathieu. http://www.mathieubriand.com/2004/sys017-rer06-pig-eqn1525/#2. [Accessed: August, 2011].

[515] Ibid.

[516] Jones, *Sensorium: Embodied Experience, Technology, and Contemporary Art.*

[517] Briand, Mathieu. http://www.mathieubriand.com/2004/sys017-rer06-pig-eqn1525/#2. [Accessed: August, 2011].

Figure 28: In “SYS*017.ReR*06/PiG-EqN\ 5*8” installation, the participants plug themselves to the sockets and see the perspectives provided by other participants.

Source: Briand, Mathieu. http://www.mathieubriand.com/2004/sys017-rer06-pig-eqn1525/#2. [Accessed: August, 2011].

Another important point is that, when the participant is plugged into the socket and another participant connects to or disconnects from the socket, his/her vision can change unexpectedly.[518] As a result of this random combination of visions, the participant may be confused and cannot understand which one is his/her perceived view. During the random switches between sockets, the participants can exchange their perspectives and also influence the audiovisual experiences of all participants.

This example alters the embodiment, where the visual perception and the physical body of the participant may seem to be separated from each other but also fold into each other. The subjectivity of the participants in selecting the socket and the decision of being plugged in or unplugged from that socket affects the perspectives and the embodiment of participants. Since, the body of the participant displaces itself in search of different visions, or the vision displaces itself according to the individual’s connections, the displacements of

[518] Jones, *Sensorium: Embodied Experience, Technology, and Contemporary Art.*

bodies and visions continually deform their experiences.[519] In relation to these attributes, this proposal can be considered as an example of a responsive environment that transforms the relation of the participant with reality and re-problematizes embodiment. This can be considered as a significant change that challenges the conception of embodiment and also the condition of the subject, since it manifests Deleuze's philosophy of the body as unstable and changing. It also delineates a change in the conception of responsive environments, where the environment is conceptualized so that it facilitates new opportunities for the body and embodiment.

This project also offers a different approach to the human-machine interaction in responsive environments. The interaction between the human and machine is different from the interaction between the human and the mechanism in the sense that the interaction process is unstable and in continuous transformation in this specific example. In the human-mechanism interaction, the mechanism responds to the human in a search for efficiency and the interaction between the human and mechanism is stable. Conversely, it can be claimed that this project manifests a Deleuzian definition of body and machine, where the connection between machines creates flows, new connections and new relations. In this respect, both the human and machine are considered as bodies and the connection between these two bodies is recognized as creating the interaction.

In this project, the interaction is not only defined between the body and the wearable computing device. The other bodies that are connected to this body through these wearable computers are also included in this interaction and one's perception is defined through its connection with another body. A flow is defined when the body connects to the sockets enabling the connection with another body and this flow is interrupted when the body is unplugged from the

[519] Ibid.

socket. Connection of the body with another socket enables its connection with a different body and hence creates a different flow. Since the perception and the experience of the body changes during these flows, a continuous production is defined during the interaction process.

Taking into consideration these redefinitions, the following section analyzes the transformations defined by machines and machinic approaches.

4.3 Transformations defined by Machinic Approaches

This chapter provided for and discussed numerous definitions of the machine. To sum up briefly, machines have been associated with mechanism, technique and the efficiency of production. However, this simplistic concept and definition of the machine has been seen to alter in machinic approaches. In these machinic approaches it is not focused on the mechanisms of the machine, but rather dealt with the transformative impact of the machine that is considered as a participant in the definition of the responsive environment.

The conception of the machine as a strategy that constructs and transforms new connections and relations has been argued to introduce new definitions and experiences of responsive environments and also alter the human-machine interaction. In this transformed interaction process, the machine can go beyond its limits, discover more than its expected outcomes, and define new flows, and relations between the bodies.

Taking into consideration these changes in the conception of the machine in responsive environments, as exemplified in the projects discussed as expressions of these machinic approaches, this section analyzes the transformations defined by these machines and machinic approaches in relation to three aspects; the altered definition of human-machine interaction, the disturbed relationship of the human with reality, and also the methodological changes initiated through these machinic approaches.

4.3.1 Disturbed Relationship of the Human with Reality

Responsive environments, which attain responsiveness through mechanisms, depend mainly on apparent laws and principles and do not pose challenges in their negotiation with reality. The real time outputs provided by the responsive mechanism mostly depend on these laws and principles and can be grasped easily by the participants in the environment. In most cases, the mechanisms imitate the experienced reality through mimicking the nature, the human, or the environment and try to attain the same experience in the responsive environment they propose. Along with that, these responsive mechanisms do not redefine and transform themselves even if they are connected to other machines or mechanisms, since they are self-enclosed systems that do not produce new connections. Consequently, it can be claimed that responsive mechanisms do not intentionally seek for new relations in their coupling with the human and do not sketch out new ways of experiencing the relationship with reality.

One of the examples that define the responsiveness of the environment and the mechanism without disturbing the participant's relationship with reality is the *fLUX* project. The *fLUX* project was designed by LAb[au] in 2008 on the border of a canal in St. Denis, Paris (figure 30).[520] The urban visualization installation is based on the measurement and real-time representation of infrastructural and communicational flows and is composed of a kinetic wall made up of rotating, luminous panels. The rotating panels and the LED lights placed on the panels are controlled by microprocessors, which are connected to

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520 Bullivant, Lucy. "LAb[au] The Generative Art of Metadesign". http://www.lucybullivant.net. [Accessed: March, 2011].

infrared sensors.[521] The sensors detect the flow of passengers, of cars and also of the electromagnetic fields produced by mobile phones and radios.[522] The data scanned from these actors are processed according to already defined rules, which create textures of the activity in the area in a wave like image.[523] The barcode-like forms created on each panel are transmitted to another panel according to the kinetic principles of waves that roll from one side to another. The provided texture creates a visual play and expresses the responsiveness of the mechanism to the environment. The human participants who experience this responsive mechanism can detect the output of the mechanism simultaneously as it merely imitates physical and kinetic principles and does not trigger the participants' relationship with reality.

Figure 29: Lab[au]: Flux, binary waves project, 2008, St Denis, Paris.

Source: Bullivant, Lucy. "LAb[au] The Generative Art of Metadesign". http://www.lucybullivant.net. [Accessed: March, 2011].

[521] Ibid.

[522] Ibid.

[523] Ibid.

Another project that proposes a responsive environment however not triggering the participant's experience of reality is the *ICE* project, which is an interactive communicative experience, designed by architects Klein Dytham and Toshio Iwai in 2002 in Tokyo (figure 31).[524] Providing an info-lounge, the *ICE* converts movements and touch into optical and acoustical outputs. It is composed of infrared lights placed behind the surface, which detect the presence of the visitor and react to his/her bodily movements.[525] The responsive interface proposes four digital play options; a harp, a shadow, a wave or a volleyball.[526] The traced inputs from the visitor in terms of movement or touch are converted into optical and acoustic signals.[527] These signals are visualized as ever-changing reflective patterns, like fire or electronic shadows.[528]

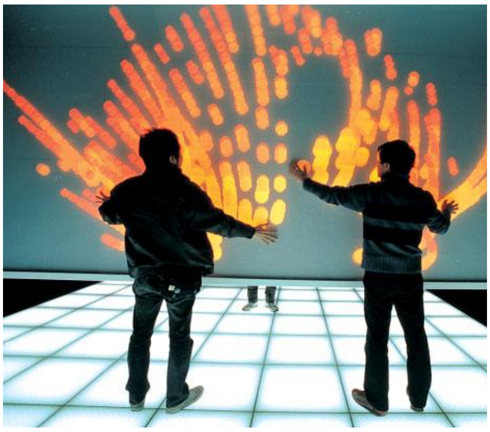

Figure 30: ICE project, 2002, Tokyo.

Source: Bullivant, Lucy. "ICE, Bloomberg Headquarters: Klein Dytham Architecture and Toshio Iwai." *AD:4dspace: Interactive Architecture*. Vol. 75 No.1 (January-February 2005): 12-14

[524] Bullivant, Lucy. "ICE, Bloomberg Headquarters: Klein Dytham Architecture and Toshio Iwai." *AD:4dspace: Interactive Architecture*. Vol. 75 No.1 (January-February 2005): 12-14

[525] Ibid.

[526] Ibid.

[527] Klein Dytham Architecture. http://www.klein-dytham.com. [Accessed: March, 2011].

[528] Ibid.

The experience proposed for the visitor can be considered as providing new insights in terms of his/her interaction with the visual patterns and a redefinition of his/her behavior in the environment after the visual outputs. However, the provided inputs or outputs do not cumulate on one another, nor are affected from the already defined or possible introductions to the mechanism. The mechanism takes into consideration the instant inputs and defines the output according to a set of relations, which are defined beforehand. The visitor experiences the outcomes of his/her performance in real time and can estimate the outputs defined by apparent principles, where the inputs provided by the visitor and the outputs provided by the mechanism share the same reality. Consequently, the installation can be considered as defining new experiences for the visitors but not triggering his/her relationship with reality.

In *An architecture "des humeurs"* project by R&Sie(n), a different experience of reality is provided through altering the relationship of the human participant with reality.[529] The reality in this specific experience is not composed of what is visible to the human, but of the hidden information of desires, dreams and expectations. The disturbance caused by a parallel reality is attained through machines, which act as both operative and fictional apparatuses and rearticulate the relation of the human with the situation and the environment. Through these machines it becomes possible to infiltrate the mind of human participants and inflect their relationships with reality.[530] Therefore, it can be claimed that *An architecture "des humeurs"* project does not imitate reality through mimicking the nature, the human, or the environment.

According to Jeanette Zwingenberger, reality in this project resembles a rhizomic growth: a continuum, which has no beginning or end, no centre and

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[529] "Architecture of Humors" project is discussed in detail in 4.2.2.section of this chapter.

[530] Corbellini, Giovanni. "Utopias of Nature, Nature of Utopias." http://www.new-territories.com/blog/architecturedeshumeurs/?p=14. [Accessed: March, 2011].

no periphery.[531] Zwingenberger states that the mathematical form of open algorithms leads to growth creating hybrid spaces, where the organic nature of desire for growth results in uncontrollable force.[532] With these characteristics *An architecture "des humeurs"* opposes the projects imitating reality, instead inflecting it through the fiction it proposes. Hence, the project aims to define fiction through scenarios while building up new conditions and deflecting the reality for the human.

4.3.2 Methodological Changes in the Architectural Design Practice

Methodological changes in the architectural design practice are considered as another important transformation introduced as a result of machinic approaches used in the definition of responsive environments. Although various methodological changes are introduced with these approaches, in this section it will be focused on the emphasis placed on the active participation of both the human and the machine in the definition of the responsive environment, the dual transformations of parties of interaction and also the redefinition of the architectural design practice.

These transformations are regarded as arising from the conception of the machine as a vector of production. In this production, the human, like the other non-human bodies involved in the process, is not considered as a user, but as a participant that involves in, affects and transforms the process. The definitions, choices or behavior of the human are included in the environment in different forms; either in the final outcome or in the simultaneous responses of the machine and the environment.

[531] Zwingenberger, "Molecular Interfaces."

[532] Ibid.

Since the human and the machine are conceptualized as participants of the process, the disturbances they define on each other would gain importance in these approaches. Remembering that machines are considered as vectors of production that can alter the experience, behavior or reaction of the human participant, they can equally alter the initial conceptions of responsive environments, where machines were (and still are in most applications) conceptualized as mechanisms and that simulate the behavior of the human being. Whereas, in machinic approaches a mutual relation between the participants can be satisfied and reflected to the environment which is defined by the interaction between participants. In machinic approaches, the human and the machine are considered as constituent parts of the environment.

In the machinic approaches used to define the responsiveness of the environment, the human goes beyond a passive involvement and actively participates in the process; s/he provides couplings with the machine, acts as a desiring machine and produces flows of information, new experiences, as well as new inputs to the responsive environment. In the meantime, the outputs of the process are defined in reference to these inputs, which in turn affect the human participant and transform his/her inputs. Therefore, the inputs and outputs of the process are defined both by the machine and the human participants that are transformed by each other.

In order to take full potential of this approach, the designer of the process needs to weaken the control over the process and embrace unpredictability, blurriness and loss of control during the interaction process to some extent. For that reason, the human and the machine are set free to reflect their behaviors upon the process. The technological apparatuses, computational design tools supporting the design process and the script running and directing the process also support this idea and let the participants define the relations and connections during the process and affect each other. Hence, the connections created between the machines, the human and the environment may offer the potential for the production of new conditions, relations and realities, which initiates a change in the definition of the interaction between the connected bodies.

4.3.3 Re-conceptualization of the Human-Machine Interaction

Emergent approaches in the research on responsive environments and the acknowledgement of machinic approaches define changes in the designation of the relations between the human and the machine as well as their interaction. These approaches have been discussed in reference to machine concepts and the philosophy of body in this chapter. Through drawing upon Deleuze's definition of body and machine, it has been underlined that the machinic approaches embrace an unstable, continuously transforming relation between the human and the machine. Their connection and the possibilities defined through these connections have been discussed in reference to Deleuze's concept of the machine particularly focusing on desiring-machines. It has been aimed to reveal that, responsive environments that are defined through machinic approaches can define the human and the machine as bodies that connect to each other and produce flows, extend their individual potentials and boundaries while integrating the other machines' potentials. This concept brings together a change in the definition of the interaction between the human and the machine in responsive environments, where the interaction between them promotes complex relationships.

Evolved in parallel to the altered definitions of body and embodiment, the human-machine interaction defines the participants as being affected from each other. The body's transformation when it encounters forces that disturb the limits of the body and embodiment is a consequence of this redefined human-machine interaction in responsive environments. This redefinition is due to the current developments in communication technologies, data transfer techniques and ubiquitously accessible databases. These developments introduce ubiquitous computing, pervasive computing and wearable computing as emergent strategies in human-machine interaction research. Enabled through these strategies, the human and the machine interact through seamless devices, transparent structures or prosthetic devices. The technological apparatuses facilitate the embodiment of the interaction process.

In responsive environments, the interaction between the human and the machine has been said to be considered as being unstable and in continuous transformation as the bodies connected to each other transform themselves and also the relations during the interaction. However, in human-mechanism interaction it is aimed to attain the effective interaction process and any instability in the interaction process is to be avoided. This is the primary departure of the human-machine interaction in responsive environments defined through machinic approaches from the human-mechanism interaction. The unstable interaction process and also the relations redefined during this transformative process can be embodied through the aforementioned strategies and tools. Embodiment of the interaction between the bodies connected to each other in a responsive environment can also be considered as another significant change in human-machine interaction.

The interaction process between the human and the machine in machinic approaches takes into account not only the physical aspects, but also the relations, contextual values or psychological aspects. Consideration of these aspects is accelerated with the introduced technological advances and computational strategies. Through the possibilities introduced, it becomes possible to define machine participants as able to alter the relationships that affect both the human and the machine and also transform the interaction process according to these changes. It needs to be remembered however that these recent developments find reflections in prior attempts at defining machines enabling these transformations such as the bachelor machine proposed by Duchamp or the *Fun Palace* designed by Cedric Price.

Despite the ongoing existence of mechanic approaches still used in the definition of responsive environments, it is possible to trace the gradual dissolution of the hierarchic order in the re-conceptualized human-machine interaction. In machinic approaches, all of the participants involved in the interaction process such as human, non-human, and machine participants, are considered as having the ability to connect to each other, alter the in-between relations and transform their counterpart. This marks a non-hierarchic relation between the actors of responsive environments. The human-machine interaction defined through machinic approaches in responsive environments stems from this non-hierarchic relation. This relation is a significant transformation experienced in the conception of human-machine interaction.

In this chapter, an overview of the debate on the machine concept has been provided and the reflections of this debate on responsive environments have been associated with machinic approaches. Underlying the differences between machines and mechanisms, as well as between machinic and mechanic approaches, this chapter considered several contemporary examples, where responsiveness is attained not through mechanisms but through machinic approaches. Each providing a different approach to the definition of responsiveness, these projects have been analyzed in reference to their definition of the machine concept. The nature of the human-machine interaction proposed in these projects has been revealed and the impact of machinic approaches on the re-definition of this interaction as well as of responsive environments have been discussed.

CHAPTER 5

CONCLUSION

The thesis questioned the ontology of the concept of responsiveness and provided in this respect, for an assessment of the nature of embodiment and the interface between the human and the machine in responsive environments. For a restructured understanding and awareness of the advances and developments affecting the concept of responsiveness and responsive environments in architecture, a multi-faceted mapping of the research field has been provided. As a significant outcome of this mapping, the thesis provided for the distinctions between different conceptions of machines and their effects on the human and the concept of responsiveness.

It has been argued that the most significant shift experienced in the definition of responsiveness and responsive environments collides with the acknowledgement of the machinic approaches in the definition of responsiveness in the last two decades. In this respect, the thesis scrutinized the machinism debate and the use of machinic approaches in responsive environments. Defining the responsive environment through machines that transcend the limits of a mechanism and discover new relations, connections and experiences, enables the embodiment of relations with regard to the body. Using the machine not only as a means for attaining an efficiency of production, but also as a means for defining an evolving, dynamic, unpredictable and indeterminate interaction process, is seen to have altered the conception of the body in responsive environments. In its altered conception, the body is continuously redefined through its interaction with the machine and the environment. The thesis traced the recent transformations in the definition of the body and the question of its embodiment, where the conception of the body can be seen to have shifted from a static to a dynamic and unstable one. Developing in parallel to this new definition of the body and the notion of embodiment, machinic approaches have re-problematized the human-machine interaction in responsive environments. The thesis has brought forth these re-problematizations as implications of significant transformations that alter both the concept of responsiveness and the definition of responsive environments.

In order to outline the changes in the conception of body and embodiment, debates in the philosophy of mind have been traced in the thesis, predominantly focusing on the Deleuzian definition of the body. References to the Deleuzian definition of the body enabled to understand and map the altered definitions and conditions of the body in responsive environments, which has been argued to display characteristics akin to the Deleuzian body, defined as its non-privileged condition and continuous transformation during its connection with the other bodies.

It is underlined in the thesis that the responsive environments defined through mechanistic approaches differ significantly from machinic approaches in their aims and methods. Mechanistic approaches do not aim to alter the definition of the body nor to define new experiences and awareness in its relations with the environment: They rather focus on the efficiency, sustainability and effectiveness of the interaction and of the processes of construction and use. In opposition, the thesis has shown that responsive environments defined through machinic approaches are altering the body and defining it as a part of the process, where the body has the equal power and ability to affect the interaction process and transform the other bodies involved in the process. This definition of the body as one of the parties in the interaction process that connects with other bodies and produces flows of interaction has been observed to reflect the Deleuzian conception of the body. The examples considered in the thesis supported this observation and enabled to better understand how the body is conceptualized in machinic approaches as a Deleuzian body.

Embracing this reconceptualization of the body, the study has shown that machinic approaches in responsive environments do not consider a hierarchic order between the participants of the interaction process. Rather, machinic approaches consider that all bodies involved in the interaction process including the environment can define connections with other bodies, trigger and redefine the relations, which initiate a non-hierarchic association. In its re-problematization, the human-machine interaction is conceptualized so that it enables this non-hierarchic association and disrupts the prevailing and central condition of the human body. This is regarded as initiating a de-centering of the human body and the consequent dissolution of anthropocentrism.

The decentralization of the human body enables the human and the machine to act in a reciprocal relationship with one another, and affect each other’s conditions and experiences. Through this way, responsive environments not only affect the definition and effectiveness of the built environment but also the ways the environment is experienced together with the condition of the human and the machine in this experience.

Conflicting with this decentralization of the human body in machinic approaches, the interaction process defined between the human and the mechanism still promotes the centering of the human, where the relationship between the human and the mechanism is not a reciprocal one. The mechanism is not considered as a participant of the interaction process that has the power to trigger relations and alter the condition, experience or behavior of the human. It is rather conceptualized so as to act according to the determined and causal relationships and not to disrupt the privileged condition of the human. Quite the opposite, the responsive environment re-embodies the human body with the complexity of the machines and distorts the centered condition of the human through defining the machine as a strategy that produces new connections, flows, interruptions, and initiates new experiences.

It is precisely in this respect that the thesis referred to Deleuzian philosophy where it is outlined that the human is not privileged with respect to the non-human and hence the human body, which is in constant redefinition itself, is not differentiated from the non-human bodies.[533] This is considered as an indication of the dissolution of anthropocentrism. The decentralization of the human body then implies the dissolution of the dichotomies between human and non-human, as well as between human and machine. Such changes propose the definition of new interfaces between the human and the machine which open up with a post-humanist context.

The thesis emphasized that the machinic approaches that inherit the Deleuzian definition of the body and embodiment within the post-humanist context, facilitate the experience of the evolving dynamic interaction process between bodies, the human and the non-human/machine. In order to discuss the ways in which this altered experience is being defined through the responsive environment, technological advances such as ubiquitous computing, sensor systems, smart materials and textiles have been studied, which enable the reflection of the bodies on the environment in different ways and call for the contribution of bodies in the definition, transformation and experience of the environment. Through the advent and development of these emergent strategies in human-machine interaction, the interaction between the human, the machine and the environment can be embodied. In the interaction process defined between the human and the mechanism through these strategies, the primary aim has been said to define the efficiency of the interaction. In human-machine interaction it is aimed to respond to the continuous transformation of bodies and relations during the interaction in order to embrace indeterminacies and

[533] Deleuze, *Spinoza, Practical Philosophy*, 127.

uncertainties and generate new connections, relations and experiences while attaining the efficiency of interaction. The thesis re-problematized and discussed the alterations caused by this approach in the definition of the body and the experience of embodiment in responsive environments.

Hence, it has been argued that comprehension of these strategies is essential to understand the potentials of responsive environments and to discuss the nature of altered experiences during interaction processes. Regarding the opportunities introduced by these strategies, the thesis stated that responsive environments may offer new definitions for the body and its embodiment, where the human and non-human participants are extended onto the environment in several ways to transform the experience of embodied relations. Extension of the body onto the environment can be experienced through its simultaneous embodiment, where the human can recognize that his/her body is not confined to its physical boundaries.[534] This extension is made possible through the inclusion of relations in the definition of embodiment, itself due to the use of emergent strategies in human-machine interaction. The thesis thus puts forward that the body in machinic approaches is re-conceptualized so that it can define, transform and experience the environment simultaneously and where it is itself continuously redefined through the environment or the other bodies involved in the interaction. The reflections of the relations defined by the participant on the environment and also on the other participants can be experienced through the machines that enable the responsiveness of the environment. This is considered as a significant transformation that entails the definition of the body as a part of the environment, where the human can experience and realize the fluctuating boundaries of his/her body.[535]

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[534] Hayles, K. "Flesh and Metal: Reconfiguring the Mindbody in Virtual Environments," Configurations. Vol. 10 No 2 (Spring. 2002): 297-320.

[535] Hayles, K. "Flesh and Metal: Reconfiguring the Mindbody in Virtual Environments," Configurations. Vol. 10 No 2 (Spring. 2002): 297-320.

In machinic approaches, these fluctuations are defined in relation to other living or non-living bodies, where both the body and the embodiment of relations emerge from the dynamic interaction process. Although the majority of the mechanistic approaches define the body as having the ability to alter the definition of the environment, they consider the body as being cut off from the environment and do not search for its definition in relation to the environment or the other bodies involved in the interaction process. In reference to these two practices, the thesis has highlighted the conception of the body as a central disparity between the machinic and the mechanistic approaches. Considering this disparity, the study has taken a positive stance for the use of machinic approaches in the definition of responsive environments, which are seen to bring forth significantly different conceptions and experiences of the body.

Through reflecting on the altered definition of the body in the human-machine interaction in responsive environments and the re-problematization of the notion of embodiment as unstable and inseparable from the environment, the thesis discussed significant methodological and epistemological transformations thereby introduced to architecture. By re-considering the concept of the machine, the mind-body relationship and also the associations between embodiment, cognition and technology, the study has marked out the transformations in the altered conceptions of body and embodiment and in the conditions of the subject and the object as consequential to a dissolution of anthropocentrism in a post-humanist philosophical framework. The discussion of these transformations enabled to expose the changes in the definition of the concept of responsiveness: Deliberately shifting the focus from the pragmatic insights of responsiveness and responsive environments to humanist concerns, the thesis sought to uncover the reflections of responsive environments defined through machinic approaches on the human condition. Hence, the extension of the discussion of human-mechanism interaction to human-machine interaction provided for a new approach into the ontology of responsiveness, revealing that responsive environments initiate significant methodological and epistemological transformations in terms of the design, practice and experience of architecture.

In this respect, the active participation of the human and the machine in the definition of the environment, the reciprocal transformations between parties involved in the interaction and the redefinition of design procedures in machinic approaches have been discussed in reference to methodological transformations in architectural design, after a thorough study of the most recent experimentations and practices in responsive architecture. These transformations experienced in architectural design practice have been observed to arise from the conception of the machine as a vector of production that is also prone to alter the modes of knowledge production in responsive environments.

The thesis also stated that the primary epistemological question in responsive environments transforms from 'who produces knowledge' to 'how knowledge is produced', as a consequence of the collaborative definition of the design process, where different parties can involve in and contribute to the production of knowledge. It is indicated that the active participation of the human and the machine in the interaction process facilitates the exchange of knowledge during the process and enables the human and the machine to cross each other's boundaries to extend their self-definitions and define new relations and experiences.

Machinic approaches define the machine participants as generators of flows, connections and interruptions and maximize their participation in the interaction process. The designer can embrace the interaction and association of the machines with the human and the environment and let them define their own set of behavioral rules in their interaction with the human and the environment, where they can also articulate different layers of information. The machine participant can therefore go beyond its mechanistic designation and define, alter or reorganize relations, hence becoming an agent to consider in the production of knowledge.

In the machinic approaches recognized in the definition of responsive environments, both the human and the machine participants produce flows of information, interactions and new experiences. They define connections and initiate the forces that interrupt these flows, where their impacts on each other set off new flows and define ‘productions of production,’ to use a Deleuzian terminology. A process of collaborative knowledge production takes place, defined by the reciprocal relationship between the parties of interaction and which makes it difficult to grasp which party produces knowledge, since each party is affected and transformed by the others.

Resting on the research carried to decipher the changing relations between the machine, the body and the environment, it has been argued that these alterations in the process introduce new conditions, relations, realities and also experiences for all participants, such as the experience of the changing boundaries of the body and the simultaneously altered conditions of embodiment, hence affecting the modes of knowledge production during the interaction processes. Thereby, it has been observed that the interaction between the machine, human and non-human bodies as well as the environment introduces new experiences of knowledge production. Although the epistemological consequences of such a process of knowledge production can be seen to be unpredictable, this has been considered as a significant epistemological change brought forth by responsive environments, where the subject and object of knowledge can no more be distinguished and new modes of knowledge production are expected to emerge. These transformations are considered as displacing the concept of responsiveness and the definition of responsive environments, while enabling the humans to recognize and experience new modes of knowledge production. Becoming a new insight for the conception of responsive environments, machinic approaches are defined as primary sources of this change.

The association put forth in the thesis between responsive environments, the machinism debate and machinic approaches, although carried out through the study of a limited number of avant-garde architectural practices in the field, revealed that responsive environments initiate significant methodological and epistemological transformations in terms of the design, practice and experience of architecture. By re-considering the concept of the machine, the mind-body relationship and also the associations between embodiment, cognition and technology, the thesis has marked out the transformations in the altered conceptions of body and embodiment and in the epistemological conditions of the subject and the object as consequential to a dissolution of anthropocentrism in a post-humanist philosophical framework.

The discussion of these transformations enabled to expose the changes in the definition of the concept of responsiveness: Critical of the pragmatism of mechanistic approaches and deliberately shifting the focus from the pragmatic insights of responsiveness and responsive environments to humanist concerns, the thesis sought to uncover the reflections of responsive environments defined through machinic approaches on the human condition. Hence, the extension of the discussion of human-mechanism interaction to human-machine interaction provided for new insights into the ontology of responsiveness.

The approach and perspective adopted in this study mainly attempted to contribute to research on the ontology of responsiveness and the nature of human-machine interaction and embodiment in responsive environments. It initiated the adoption of a philosophical framework for understanding responsiveness, the extensions of which are expected to contribute further to the research field, replacing and overcoming the shortcomings of pragmatic/pragmatist approaches that have been seen to govern studies in responsive systems/environments.

BIBLIOGRAPHY

Addington, D. Michelle. *Smart Materials and New Technologies: For the Architecture and Design Professions*. Boston: Architectural Press, 2005.

Alanen, Lilli. *Descartes's Concept of Mind.* Cambridge, Mass.: Harvard University Press, 2003.

Allen, Colin. *Species of Mind: The Philosophy and Biology of Cognitive Ethology.* Cambridge, Mass.; London : MIT, 1999.

Anderson, Michael L. "Embodied Cognition: A Field Guide." *Artificial Intelligence*. Vol:149 No.1 (2003): 91-130.

Anshuman, Sachin. "Responsiveness and Social Expression; Seeking Human Embodiment in Intelligent Façades." in *Annual Conference of the Association for Computer Aided Design In Architecture*. Proceedings, 13-16. Savannah (Georgia), 2005.

Archinect. "Philippe Rahm." http://archinect.com/features/article/96362/philippe-rahm-part-1. [Accessed: August, 2011].

Ariew, Roger. *Readings in Modern Philosophy: Descartes, Spinoza, Leibniz, and Associated Texts*. Indianapolis: Hackett Pub. Co., 2000.

Ashby, W. Ross. *An Introduction to Cybernetics*. London: Methuen & Co., 1964.

Asquith, Lindsay and Vellinga, Marcel. “Introduction.” *Vernacular Architecture in the Twenty-first Century: Theory, Education and Practice*. London; New York: Taylor & Francis, 2006.

Atkin, Brian. “Progress Towards Intelligent Buildings.” In *Intelligent Buildings.* New York: John Wiley & Sons, 1988.

Aukstakalnis, Steve and Blatner, David. *Silicon Mirage; The Art and Science of Virtual Reality*. Berkeley, CA: Peachpit Press. 1992.

Baker, Gordon P. and Morris, Katherine. *Decartes' Dualism*. London, New York: Routledge, 2002.

Barfield, Woodrow and Caudell, Thomas. “Preface.” *Fundamentals of Wearable Computers and Augumented Reality*. Mahwah, NJ: Lawrence Erlbaum Associates, 2001.

Bechtel, W. and Abrahamsen, A. “Explanation: A Mechanist Alternative.” *Studies in the History and Philosophy of the Biological and Biomedical Sciences*. Vol. 36 No. 2 (June 2005): 421–441.

Bechtel, W. and Abrahamsen, A. ‘From Reduction Back to Higher Levels,’ in *30th Annual Conference of the Cognitive Science Society,* Proceedings, 559-564. Austin, Texas, 2008.

Beilharz, Kirsty. “Responsive Sensate Environments: Past and Future Directions: Designing Space as an Interface with Socio-Spatial Information.” In *11th International Conference on Computer Aided Architectural Design Futures,* Proceedings, 361-370. Austria, 2005.

Biloria, Nimish and Oosterhuis, Kas. “Envisioning the Responsive Milieu: An Investigation into Aspects of Ambient Intelligence, Human Machine Symbiosis and Ubiquitous Computing for Developing a Generic Real-time Interactive Spatial Prototype,” in *10th International Conference on Computer Aided Architectural Design Research in Asia (CAADRIA),* Proceedings, 421-432. India, 2005.

Biloria, Nimish. “Developing Concept Prototypes for Electronic Media Augmented Spatial Skins-An Investigation into Biotic Processes, Material Technologies and Embedded Computation for Developing Intelligent Systemic Networks” in *9th International Conference on Computer Aided Architectural Design Research in Asia*, Proceedings, Seoul Korea, 2004.

Biloria, Nimish. “Emergent Technologies and Design: An Investigation into Biotic Processes, Material Technologies and Embedded Computation for Developing Intelligent Systemic Networks,” in *23rd eCAADe Conference (Education and research in Computer Aided Architectural Design in Europe),* Proceedings, 441-447. Lisbon, 2005.

Biloria, Nimish. “Spatializing Real Time Interactive Environments.” in *1st International Conference on Tangible and Embedded Interaction,* Proceedings, 215-222. USA, 2007.

Bock, Peter, “The Emergence of Artificial Intelligence: Learning o Learn.” *The AI Magazine*. Vol.6 No.3: (Fall 1985): 180-190.

Boden, Margaret A. *Artificial Intelligence and Natural Man.* New York: Basic Books Inc., 1977.

Bouquiaux, Laurence. *On A Mathematical 'Neo-Aristotelism' in Self-Organization and Emergence in LifeSciences*. Eds. Bernard Feltz, Marc Crommelinck and PhilippeGoujon. Dordrecht: Springer, 2006.

Briand, Mathieu. http://www.mathieubriand.com/2004/sys017-rer06-pig-eqn1525/#2. [Accessed: August, 2011].

Bullivant, Lucy. "ADA: The Intelligent Room." *AD: 4dspace: Interactive Architecture.* Vol. 75 No. 1 (January-February 2005): 96-90.

Bullivant, Lucy. "ICE, Bloomberg Headquarters: Klein Dytham Architecture and Toshio Iwai." *AD:4dspace: Interactive Architecture*. Vol. 75 No.1 (January-February 2005)12-14

Bullivant, Lucy. "Alice in Technoland." *AD: 4dsocial: Interactive Design Environments.* Vol. 77 No. 4 (July 2007): 6-13.

Bullivant, Lucy. *Responsive Environments: Architecture, Art and Design*. London: Victoria and Albert Museum, 2006.

Bullivant, Lucy. "LAb[au] The Generative Art of Metadesign". http://www.lucybullivant.net. [Accessed: March, 2011].

Cahn, Steven M. *Classics of Western Philosophy*. Indianapolis: Hackett Pub. Co., 2006.

Campbell, Christopher, Chan, Denise M. and Miner, Cameron S. "Digital Jewellery: Wearable Technology for Everyday Life." in *Conference on Human Factors in Computing Systems*. Proceedings, 45-46. Washington, 2001.

Carrouges, Michel. “Directions for Use.” *Le Macchine Celebi/The Bachelor Machines*. New York: Rizzoli, 1975.

Cepezed. http://www.cepezed.nl. [Accessed: March, 2011].

Charniak, Eugene and McDermott, Drew. *Introduction to Artificial Intelligence*. Mass.: Addison-Wesley Publishing Company, 1985.

Churchland, Paul M., *Matter and Consciousness: A Contemporary Introduction to the Philosophy of Mind*. Cambridge, Mass.: MIT Press, 1988.

Clark, Andy and David Chalmers. “The Extended Mind.” Analysis. Vol. 58 No.1 (1998): 7-19.

Colebrook, Claire. *Gilles Deleuze*. London; Routledge, 2002.

Corbellini, Giovanni. Bioreboot: The Architecture of R&Sie(n). New York: Princeton Architectural Press, 2009.

Corbellini, Giovanni. ‘‘Utopias of Nature, Nature of Utopias.” http://www.new-territoriescom/blog/architecturedeshumeurs/?p=14. [Accessed: March, 2011].

Crinson, Mark. “In the Bowels of the Fun Palace.” *Mute Magazine*, 2008. http://www.metamute.org/en/html2pdf/view/11006A. [Accessed: March, 2011].

Crossley, Nick. *The Social Body: Habit, Identity and Desire*. London: Sage, 2001.

Cunningham, Suzanne. What *is a Mind?: An Integrative Introduction to the Philosophy of Mind.* Indianapolis: Hackett Publishing Co., 2000.

Custance, Arthur C. and Travis, Lee Edward. *The Mysterious Matter of Mind.* Texas: Zondervan Publishing Co., 1979.

Dawson, Michael. *Understanding Cognitive Science.* Malden, Mass.: Blackwell, 1998.

De Landa, Manuel. *Deleuze: History and Science*. New York: Atropos Press, 2010.

De Landa, Manuel. *War in the Age of Intelligent Machines*. New York: Zone Books, 2003.

d'Estrée Sterk, Tristan. "Using Actuated Tensegrity Structures to Produce a Responsive Architecture." In *Annual Conference of the Association for Computer Aided Design In Architecture*, Proceedings, 85-93. India, 2003.

Deleuze, Gilles, and Guattari, Felix. *Anti-Oedipus: Capitalism and Schizophrenia*. Trans. Robert Hurley, Mark Seem, and Helen R. Lane, Minneapolis: University of Minnesota Press, 1983.

Deleuze, Gilles. *Spinoza, Practical Philosophy*. San Francisco: City Lights Books, 1988.

Deleuze, Gilles, Guattari, Felix. *A Thousand Plateaus: Capitalism and Schizophrenia*. Minneapolis: Continuum International, 2004.

Deleuze, Gilles. *The Fold: Leibniz and the Baroque*. London; New York: Continuum, 2006.

Descartes, Rene. *Descartes' Philosophical Writings.* Trans. Norman Kemp Smith, London: Macmillan, 1952.

Descartes, René. *Discourse on Method and the Meditations*. Baltimore, Penguin. 1968.
Descartes, René. "Meditations on First Philosophy." *The Philosophical Writings of René Descartes*. Trans. J. Cottingham, R. Stoothoff and D. Murdoch, Cambridge: Cambridge University Press, 1984.

Diniz, Nancy, Cesar Branco, Miguel Sales Dias and Alasdair Turner. "Morphosis: A Responsive Membrane," in *12th International Conference on Computer Aided Architectural Design Futures.* Proceedings, 489-498. Australia, 2007.

Dourish, Paul. "Embodied Interaction: Exploring the Foundations of a New Approach to HCI."1999. http://www.dourish.com/publications.html. [Accessed: April, 2011].

Dourish, Paul. *Where the Action Is: The Foundations of Embodied Interaction.* Cambridge, Mass.: MIT Press, 2004.

Dudek, Gregory and Jenkin, Michael. *Computational Principles of Mobile Robotics*. New York: Cambridge University Press, 2000.

Dunne, Lucy E. "Minimally Invasive Sensing of Body Position and Movement Using Body-Garment Interactions." PhD diss., National University of Ireland, 2007.

Dwinght Holland, Dawn J. Roberson and Woodrow Barfield. "Computing Under the Skin." Fundamentals of Wearable Computers and Augmented

Reality. Eds. Woodrow Barfield, Thomas Caudell. Mahwah, NJ: Lawrence Erlbaum Associates, 2001.

Dwinght Holland, Dawn J. Roberson and Woodrow Barfield. "Computing Under the Skin."_*Fundamentals of Wearable Computers and Augumented Reality*. Mahwah, NJ : Lawrence Erlbaum Associates, 2001.
Eastman, C. "Adaptive-Conditional Architecture." In *Design Research Society's Conference*, Proceedings, 51-57. Manchester, 1971.

Elrod, Scott, Hall, Gene, Costanza, Rick, Dixon, Michael, Des Rivières, Jim. "Responsive Office Environments." *Communications of the ACM*. Vol. 36 No. 7 (July 1993): 84-85.

Eng, K and Douglas, R J and Verschure, P. F. M. J. "An Interactive Space that Learns to Influence Human Behaviour." in *IEEE Transactions on Systems, Man, and Cybernetics*, Proceedings, 66-77. 2005.

Eng, K., Baebler, A., Bernardet, U., Blanchard, M., Briska, A., Costa, M., Delbruck, T., Douglas, R., Hepp, K., Klein, D., Manzolli, J., Mintz, M., Netter, T., Roth, F., Wassermann, K., Whatley, A., Wittmann, A. and Verschure, P. "Ada: Buildings as Organisms." in *Game, Set, Match,* Proceedings, 33-44. Netherlands, 2003.

Eng, K., Baebler, A., Bernardet, U., Blanchard, M., Costa, M., Delbruck, T., Douglas, R.J., Hepp, K., Klein, D., Manzolli, J., Mintz, M., Roth, F., Rutishauser, U., Wassermann, K., Whatley, A.M., Wittmann, A., Wyss, R., and Verschure, P.F.M.J. "Ada – Intelligent Space: An artificial creature for the Swiss Expo.02." in *IEEE/RSJ International Conference on Robotics and Automation*, Proceedings, 4154-4159.Taipei, 2003.

Eng, K., Mintz, M., Verschure, P.F.M.J. "Collective Human Behavior in Interactive Space." In *IEEE Conference on Robotics and Automation*, Proceedings, 2057-2062. Spain, 2005.

Evans, Christopher Riche. *Cybernetics*. Baltimore, University Park Press, 1968.

Falk, Jennica, Redström, Johan, and Björk, Staffan. "Amplifying Reality." in *1st International Symposium on Handheld and Ubiquitous Computing.* Proceedings, 274-281. Karlsruhe, Germany, 1999.

Floridi, Luciano. *Philosophy and Computing: An Introduction*. London and New York: Routledge. 1999.

Floridi, Luciano. *Philosophy and Computing: An Introduction***.** London, New York: Routledge, 1999.

Floridi, Luciano. *The Blackwell Guide to the Philosophy of Computing and Information.* Malden, MA: Blackwell Pub., 2004.

FoAM. http://www.f0.am/tgarden. [Accessed: January, 2011].

Fox, Michael and Kemp, Miles.*Interactive Architecture*. Princeton Architectural Press, 2009.

Frazer, John. "Computing Without Computers." *AD: The 1970s is Here and Now.* Vol. 75.No. 2 (March-April 2005): 34-43.

Frazer, John. "The Co-operative Evolution of Buildings and Cities." in *CoBuild '98,The First International Workshop on Cooperative Buildings, Integrating Information, Organization, and Architecture*. Proceedings, 130-141. London, 1998.

Furtado, Gonçalo M.. “Cedric Price’s Generator and the Frazers’ Systems Research.” *Technoetic Arts: A Journal of Speculative Research.* Vol.6 No.1 (March 2008): 55-72.

Galbraith, J.A. and Haughton, S. *Manual of Mechanics*. London: Cassell, 1871.

Gallagher, Shaun and Zahavi, Dan. *The Phenomenological Mind: An Introduction to Philosophy of Mind and Cognitive Science*. London, New York: Routledge, 2008.

Gardner, Howard. *The Mind's New Science: A History of the Cognitive Revolution.* New York: Basic Books, 1987.

Gellersen, Hans Werner. “Augmenting Everyday Artefacts with Shared Awareness.” in *Information Society Technologies IST'2000.* Proceedings. Brussels, Belgium, 2000.

Gerovitch, Slava. “Love-Hate for Man-Machine Metaphors in Soviet Physiology: From Pavlov to Physiological Cybernetics." *Science in Context*. Vol. 15 No. 2 (2002): 339-374.

Gibbs, Raymond W. *Embodiment and Cognitive Science*. Cambridge: Cambridge University Press, 2005.

Glanville, Ranulph. “And He was Magic.” *Kybernetes.* Vol.30 No. 5/6 (2001): 652-672.

Glennan, Stuart.‘Modeling Mechanisms.’ *Studies in the History and Philosophy of Biology and Biomedical Sciences.* Vol. 36 No. 2 (June 2005): 443-464.

Glennan, Stuart.‘Rethinking Mechanistic Explanation.’ *Philosophy of Science*. Vol. 69 No.3 (September 2002): 342-353.

Goodeve, Thomas. M. *The Elements of Mechanism*. London: Longman and Green, 1912.

Gottfredson , Linda. “Mainstream Science on Intelligence.” *The Wall Street Journal*. http://www.udel.edu/educ/gottfredson/reprints/1994WSJmainstream.pdf. [Accessed: March, 2011].

Guignon, Charles. *Heidegger and the Problem of Knowledge*. Indianapolis, Ind.: Hackett Pub. Co., 1983.

Hansen, Lone Koefoed and Wamberg, Jacob. “Interface or Interlace?: Or How Art Is Mediated in Augmented Reality.” in *Digital Arts & Culture 2005 Conference: Digital Experience: Design, Aesthetics, Practice*. Proceedings, 161-169. Denmark, 2005.

Haque, Usman. “Architecture, Interactions, Systems.” *AU: Arquitetura & Urbanismo*, No149, 2006.

Haque, Usman. “Distinguishing Concepts: Lexicons of Interactive Art and Architecture.” *AD: 4dsocial: Interactive Design Environments*. Vol. 77 No. 4 (July 2007): 24-31.

Haque, Usman. “The Architectural Relevance of Gordon Pask.” *AD: 4dsocial: Interactive Design Environments*. Vol. 77 No. 4 (July 2007): 54-61.

Haslebo, Gitte and Nielsen, Kit Sanne. “Key Concepts in Systemic Thinking.” *Systems and Meaning: Consulting in Organizations*. London: Karnac Books, 2000.

Haugeland, John. “The Nature and Plausibility of Cognitivism.” *Behavioral and Brain Sciences.* Vol.1 No. 2 (1978): 215-260.

Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics.* Chicago, Ill.: University of Chicago Press, 1999.

Hayles, K. “Flesh and Metal: Reconfiguring the Mindbody in Virtual Environments,” Configurations. Vol. 10 No 2 (Spring. 2002): 297-320.

Heidegger, Martin. *Being and Time*. Albany, NY: State University of New York Press, 1996.

Henderson, Linda Dalrymple. “Etherial Bride and Mechanical Bachelors: Science and Allegory in Marcel Duchamp's "Large Glass.” *Configurations*. Vol. 4 No. 1 (Winter 1996): 91-120.

Henderson, Linda Dalrymple. *Duchamp in Context: Science and Technology in the Large Glass and Related Works*. Princeton University Press. 1998.

Heylighen, Francis and Joslyn, Cliff. “Cybernetics and Second-Order Cybernetics.” *Encyclopedia of Physical Science & Technology*. New York: Academic Press, 2001.

Hookway, B. and Perry, C. “Responsive Systems | Appliance Architectures.” *AD: Collective Intelligence in Design*. Vol. 76 No. 5 (December 2006): 74-79.

Jansen, Theo. http://www.strandbeest.com. [Accessed: March, 2011].

Jones, Andrew. *Archaeological Theory and Scientific Practice*. Cambridge; New York: Cambridge University Press, 2002.

Jones, Caroline A. *Sensorium: Embodied Experience, Technology, and Contemporary Art*. Cambridge, Mass.: MIT Press : The MIT List Visual Arts Center, 2006.

Joseph, Branden Wayne. Random Order: Robert Rauschenberg and the Neo-Avant-Garde. Cambridge, Mass.: MIT Press. 2003.

Khan, Ned. http://nedkahn.com/wind.html#fragmentedSea. [Accessed: March, 2011].

Kiel, Moe. *Thermally Active Surfaces in Architecture*. New York: Princeton Architectural Press 2010.

Kim, Jong Jin. "Intelligent Building Technologies; A Case of Japanese Buildings." *The Journal of Architecture*. Vol. 1 No. 2 (Summer 1996): 48-164.

Krauss, Rosalind. "Bachelors." *October*. Vol. 52 (Spring, 1990): 52-59.

Lamming, Mik, Brown, Peter, Carter, Kathleen, Eldridge, Margery, Flynn, Mike and Louie, Gifford. "The Design of a Human Memory Prosthesis." *The Computer Journal.* Vol. 37 No. 3 (1994): 153-163.

Landau, Royston. "A Philosophy of Enabling." *Cedric Price, Works II*. London: Architectural Association, 1984.

Lanigan, Richard L. *Phenomenology of Communication: Merleau-Ponty's Thematics in Communicology and Semiology.* Pittsburgh: Duquesne University Press, 1988.

Leibniz, Freiherr von Gottfried Wilhelm. *Discourse on Metaphysics and Other Essays*. Indianapolis: Hackett, 1991.

Leibniz, Gottfried Wilhelm, Freiherr von. *Discourse on Metaphysics, and The Monadology***.** Mineola, N.Y.: Dover Publications, 2008.

Leibniz, Gottfried Wilhelm, Freiherr von. *New Essays on Human Understanding*. Cambridge: Cambridge University Press, 1996.

Leung, Wai-Lun Danny, Li, Zheng and Ayhan, Bülent. "Intelligent Space with Time Sensitive Applications." http://ieeexplore.ieee.org/iel5/10040/32215/01511209.pdf. [Accessed: March, 2011].

Littlewood, Joan. "A Laboratory of Fun." *New Scientist*. Vol. 22 No. 391 (May 1964): 432-33.

Lobsinger, Mary Lou. "Cedric Price: An Architecture of Performance." *Daidalos.* Vol. 74 (2000): 22-29.

Low, Setha M. and Lawrence-Zúñiga, Denise**.** *The Anthropology of Space and Place: Locating Culture*. Malden, MA : Blackwell Pub., 2003.

Ludwig, Kirk. "The Mind-Body Problem: An Overview." *The Blackwell Guide to Philosophy of Mind.* Eds. Stephen P. Stich, Ted A. Warfield. Wiley-Blackwell, 2003.

Lycan, William G. "The Mind-Body Problem." *The Blackwell Guide to Philosophy of Mind*. Eds. Stephen P. Stich, Ted A. Warfield. Wiley-Blackwell, 2003.

Machamer, P., Darden, L. and Craver, C.: 'Thinking about Mechanisms.' *Philosophy of Science*. Vol. 67 No. 1 (March 2000): 1-25.

Machamer, Peter. ‘Activities and Causation: The Metaphysics and Epistemology of Mechanisms.’ *International Studies in the Philosophy of Science*. Vol. 18 No. 1 (March 2004): 27-39.

Massumu, Brian. “Realer than Real: The Simulacrum According to Deleuze and Guattari.” http://www.opa-a2a.org/dissensus/wp-content/uploads/2008/04/massumi_brian_realer_than_real.pdf. [Accessed: August, 2011].

Mathews, Stanley. “The Fun Palace as Virtual Architecture Cedric Price and the Practices of Indeterminacy.” *Journal of Architectural Education.* Vol.59 No.3 (February 2006): 39-48.

May, Todd. *Gilles Deleuze: An Introduction*. New York: Cambridge University Press, 2005.

Merleau-Ponty, M. *Phenomenology of Perception*. London: Routledge and Kegan Paul, 1962.

Metropolismag. “Living, Breathing Buildings: Envisioning Architecture that Performs Like Natural Organisms.” http://www.metropolismag.com/story/20051219/living-breathing-buildings. [Accessed: March, 2011].

Morris, Joseph. *A New Natural Theology; Based Upon the Doctrine of Evolution*. Memphis: General Books LLC, 2010.

Mumford, Lewis. *The Myth of the Machine*. New York: Harcourt, Brace & World, 1967.

Mura,Gökhan. “Wearable Technologies for Emotion Communication.” *Metu Journal of the Faculty of Architecture*. METU: Ankara. Vol. 25 No. 1 (2008):153-161.

Nadel, Lynn and Piattelli-Palmarini, Massimo. “What is Cognitive Science?” *Encyclopedia of Cognitive Sceince*. London, Nature Pub. Group, 2003.

Nadel, Lynn. *Encyclopedia of Cognitive Science*. London; New York: Nature Pub. Group, 2003.

Negroponte, Nicholas. *Soft Architecture Machines*. Cambridge, MA: MIT Press, 1975.

Negroponte, Nicholas. *Being Digital*. New York: Knopf, 1995.

Nowland, J. “Smart Shirts to Revolutionize Healthcare.”2003. http://www.chinapost.com.tw/business/detail.asp?ID=42338&GRP=E. [Accessed: May, 2011].

Oosterhuis, Kas and Xia, Xin. *iA: No. 1 (Interactive Architecture)*. Ram Distribution, 2007.

Oosterhuis, Kas and Xia, Xin. *iA: No. 2 (Interactive Architecture)*. Episode Publishers, 2008.

Pask, Gordon. *An Approach to Cybernetics.* New York, Harper , 1961.

Pask, Gordon. “A Comment, A Case History and a Plan.” *Cybernetics, Art and Ideas*. London: Studio Vista,1971.

Pask, Gordon. “Architectural Relevance of Cybernetics.” *Architectural Design*. (September 1969): 494-496.

Pask, Gordon. “Musicolour.” *The Scientist Speculates. An Anthology of Partly-Baked Ideas*. Eds. Good I.J. New York: Basic Books (1962): 135-137.

Pentland, Alex. "Smart Rooms." *Scientific American Magazine*. *(*April 1996): 68-76.

Plato. *Plato's Phaedo.* Cambridge: Cambridge University Press, 1980.

Plato. *Timaeus; Critias; Cleitophon; Menexenus; Epistles.* Trans. R. G. Bury. Cambridge, Mass.: Harvard University Press, 1999.

Price, Cedric. *Re CP*. Basel, Boston: Birkhauser, 2003.

Price, Cedric. *The Square Book*. Chicester, West Sussex: Wiley-Academy, 2003.

R&Sie(n). “An Architecture of Humors,” Tresholds. Cambridge: MIT Press. No:38 (2010): 14-26.

Radical Craft. http://www.radical-craft.com/.[Accessed: March, 2011].

Rahm, Philippe. http://www.philipperahm.com/data/projects/hormonorium /index.html. [Accessed: August, 2011].

Rattenbury, Kester. *Cedric Price: Potteries Thinkbelt***.** Abingdon: Taylor & Francis Group, 2007.

Reece, Peter L. *Progress in Smart Materials and Structures*. New York: Nova Science Publishers, 2007.

Reef. http://www.reefseries.com/.[Accessed: March, 2011].

Rendell, Jane. *Art and Architecture: A Place Between*. London; New York : I.B. Tauris. 2006.

Reuleaux, Franz. *The Kinematics of Machinery: Outlines of a Theory of Machines*. New York: Dover Publications, 1963.

Riley, Terence. *The Changing of the Avant-Garde: Visionary Architectural Drawings from the Howard Gilman Collection.* New York: Museum of Modern Art, 2002.

Robinson, Howard. "Dualism." *The Blackwell Guide to Philosophy of Mind*. Eds. Stephen P. Stich, Ted A. Warfield. Wiley-Blackwell, 2003.

Roche, François. Interview by author. Tape recording. Paris, January 13, 2011.

Roche, François. "(Science) Fiction, Ecosophical Apparatuses and Skizoid Machines: Animisim, Vitalism and Machinisim as a Way to rearticulate the need to Confront the Unknown in a Contradictory Manner." *AD: Ecoredux.* Vol. 80 No. 6 (November-December 2010): 64-71.

Roche, François. "Bodies without Organs-BwO." *AD: Neoplasmatic Design.* Vol. 78 No. 6 (November-December 2008): 68-69.

Roche, François. "Alchimis(t/r/ick)-machines." http://www.new-territories.com/roche%20text.htm. [Accessed: March, 2010].

Roche, François. "An architecture "des humeurs." http://www.new-territories.com/blog/architecturedeshumeurs/?p=14 [Accessed: January, 2011].

Roche, François. Interview by Anna Neimark. http://arch.usc.edu/content/pages/cm/uploadedmedia/idnws_fall_091268772390613.pdf [Accessed: January, 2011].

Roosegaarde, Daan. "Dune 4.0." http://www.studioroosegaarde.net/. [Accessed: March, 2011].

Rupert, Robert D. *Cognitive Systems and the Extended Mind*. New York: Oxford University Press, 2010.

Russell, Stuart J. and Norvig, Peter. *Artificial Intelligence: A Modern Approach*. N.J.: Upper Saddle River, 2003.

Schalkoff, Robert J. *Artificial Intelligence: An Engineering Approach.* New York: McGraw-Hill, 1990.

Schick, Lea and Malmborg, Lone. "Unfolding and Refolding Embodiment into the Landscape of Ubiquitous Computing." in *Digital Art and Culture Conference_ After Media: Embodiment and Context*. Proceedings, California, 2009.

Schick, Lea and Malmborg, Lone. "Bodies, Embodiment and Ubiquitous Computing." *Digital Creativity*. Vol.21 No.1 (May 2010): 63-69.

Schwarz, Arturo. *The Complete Works of Marcel Duchamp*. Delano Greenidge Editions, 1997.

Science Ahead. http://www.scienceahead.com/page/36/. [Accessed: April, 2011].

Searle, John R. *Mind: A Brief Introduction*. Oxford, New York: Oxford University Press, 2004.

Sensatex. http://www.sensatex.com/. [Accessed: April, 2011].

Sha, Xin Wei. "The TGarden Performance Research Project." *Modern Drama, Special Issue: Technology.* Vol. 48 No. 3 (Fall 2005): 585-608.

Sha, Xin Wei. “Resistance Is Fertile: Gesture and Agency in the Field of Responsive Media.” *Configurations.* Vol. 10 No. 3 (Fall 2002): 439-472.

Sherbini, Khaled and Krawczyk, Robert. “Overview of Intelligent Architecture.” In *eDesign in Architecture: ASCAAD's First International Conference on Computer Aided Architectural Design*, Proceedings, Saudi Arabia, 2004.

Smailagic, Asim. "Wearable Computers: A New Paradigm in Computer Systems and Their Applications." *IEEE Transactions on Computers.* Vol. 52, No. 8 (August 2003): 977-978.

Tarnas, Richard. *The Passion of the Western Mind: Understanding the Ideas That Have Shaped Our World View.* New York: Ballantine.1991.

Thagard, Paul. *Mind: Introduction to Cognitive Science*. Cambridge, Mass.: MIT Press, 2005.

Thelen, Esther, Schoner, Gregor, Scheier, Christian, and Smith, Linda B. “The Dynamics of Embodiment: A Field Theory of Infant Perservative Reaching.” *Behavioral and Brain Sciences*. Vol.24 No.1 (2001): 1-34.

Uttal, William R. *Dualism: The Original Sin of Cognitivism*. N.J.: L. Erlbaum Associates, 2004.

Vallino, James R. “Interactive Augmented Reality.” PhD diss., University of Rochester, 1998.

Van Gelder, Timothy. “Dynamics and Cognition.” *Mind Design II: Philosophy, Psychology, and Artificial Intelligence*. Eds. John Haugeland, Cambridge, Mass.: MIT Press, 1997.

Varela, Franscisco J., Thompson, Evan T. and Rosch, Eleanor. *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge, Mass.: MIT Press, 1992.

von Foerster, Heinz. *The Cybernetics of Cybernetics.* Minneapolis: FutureSystems Inc. 1995.

Weiser, Mark, Gold, Rich and Brown, John Seely. "The Origins of Ubiquitous Computing Research at PARC in the late 1980s," IBM Systems Journal Vol. 38 No.4 (December 1999): 636-639.

Weiser, Mark. "Some Computer Science Issues in Ubiquitous Computing." *Communications of the ACM*. Vol. 36 No. 7 (July 1993): 75-84.

Weiser, Mark."The Computer of the 21th Century." *Readings in Human-Computer Interaction: Toward the Year 2000.* San Francisco, Calif.: Morgan Kaufmann Publishers, 1995.

Wiener, Norbert. "Cybernetics in History." *The Human Use of Human Beings: Cybernetics and Society*. Boston: Houghton Mifflin. 1954.

Wiener, Norbert. *Cybernetics: Or Control and Communication in the Animal and the Machine.* Cambridge: MIT Press, 1961.

Wigley, Mark. "Exhibition: Cedric Price - The Fun Palace," Curatorial Statement, Columbia University: Arthur Ross Architecture Gallery, Buell Hall, September 19, 2005. http://www.arch.columbia.edu/gsap/54880. [Accessed: March, 2010].

Wilken, Rowan. *"*Calculated Uncertainty: Computers, Chance Encounters, and 'Community' in the Work of Cedric Price." *Accidental Environments.* No. 14, 2007.http://transformationsjournal.org/journal/issue_14/article_04.shtml. [Accessed: March, 2011].

William Bechtel and Adele Abrahamsen. 'From Reduction Back to Higher Levels.' in *30th Annual Conference of the Cognitive Science Society,* Proceedings, 559-564. Austin, Texas, 2008.

Willis, Robert. *Principles of Mechanism*. London: Oxford University Press, 1951.

Winston, Patrick Henry. *Artificial Intelligence*. Mass.: Addison-Wesley Publishing Company, 1984.

Wright, Georg Henrik. *In the Shadow of Descartes: Essays in the Philosophy of Mind*. Dordrecht; Boston: Kluwer Academic Publishers, 1998.

Wysocki, Bernard. "In Sickness and Health, Biometrics Field Grows." Wall Street Journal. 2011. http://startupjournal.com/columnists/challengers/ bodymedia/2001081Owysocki.html. [Accessed: May, 2011].

York,J and Pendharkar, Parag C. "Human-Computer Interaction Issues for Mobile Computing in a Variable Work Context." *International Journal of Human-Computer Studies*. Vol. 50 No. 5-6 (May 2004): 771-797.

Zwingenberger, Jeanette. "Molecular Interfaces." *Movement*. No. 54 (2010).

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PUBLICATIONS

Year	Publication
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2010	Uçar, Başak. & Kömez, Esin. "Assessment of Urban Performance in Computational Design Environment", Proceedings of 1st International Graduate Research Symposium on the Built Environment, METU, Ankara, 2010.
2010	Uçar, Başak. "Non-visualization and Delay of Formal Expression in Computational Diagram Practices", Proceedings of the 13th International Congress of Architectural Graphic Expression, Polytechnic University of Valencia, 2010.
2007	Uçar, Başak. "Redefinition of the Architectural Representation Process: Simultaneous Representation through Responsive Systems", Proceedings of the Seventh International Postgraduate Research Conference in the Built and Human Environment, UK, University of Salford, 2007.

ACADEMIC FELLOWSHIPS AND AWARDS

Year	Publication
2009	May 19th, 2009 – November 20th, 2009: TÜBİTAK-PhD International Research grant, TU Delft_Department of Architecture Building Technology Program.
2004	"Open Space-People Space" International Student Competition, 2nd Prize (with Duygu Şener, Elçin Ertuğrul and Övünç Tarakçıoğlu).
2004	"Concrete Design Competition" International Student Competition | National Round, 2004, 1st Prize (with Tuba Karpuzoğlu and Güney Çıngı).
2004	"TSMD Student Competition", 2004, 1st Prize.

COMPETITIONS AND WORKSHOPS

Competitions

2007 "Antalya, Konyaaltı Nature and Culture Park Design Project Competition," National. (with Mert Ayaroğlu)

2006 "Hobart Waterfront Design Ideas Competition," International. (with C. Abdi Güzer, Lale Özgenel and Yeşim Hatırlı)

2006 "The National Library of Czech Republic," International. (with C. Abdi Güzer, Lale Özgenel and Yeşim Hatırlı)

2005 "IFDA" (The International Furnishings and Design Association), International. (with Tuba Karpuzoğlu, Güney Çıngı and Mert Ayaroğlu)

2004 "Bursa Kızyakup Urban Re-Development Project," National. (with Tuba Karpuzoğlu, Duygu Şener and Güney Çıngı)

2004 "Open Space-People Space," International. 2nd Prize. (with Duygu Şener, Elçin Ertuğrul and Övünç Tarakçıoğlu)

2004 "Concrete Design Competition," National. 1st Prize. (with Tuba Karpuzoğlu and Güney Çıngı)

2004 "TSMD Student Competition," National. 1st Prize.

Workshops

2007 "Virtual | Real," by Assoc. Prof. Dr. Arzu Gönenç Sorguç, Res. Asst. Başak Uçar, Res. Asst. Gökhan Kınayoğlu and Neriman Kaya, METU, Department of Architecture. **National_(Organizer)**

2004 "Open Space-People Space_Inclusive Design for Outdoor Environments", by the University of Edinburgh, Department of Architecture, Edinburgh, Scotland. **International_(Participant)**

2004 "Concrete Design Master Class on Robustness"_ by the Berlage Institute, Netherlands. **International_(Participant)**

2004 “Time and space _virtual dynamics”, by Warp-DS (Nilüfer Kozikoğlu, Müge Belek and Federico Fialho), METU, Department of Architecture. **National_(Participant)**

LANGUAGES

Turkish (mother tongue), English (fluent), German (beginner)